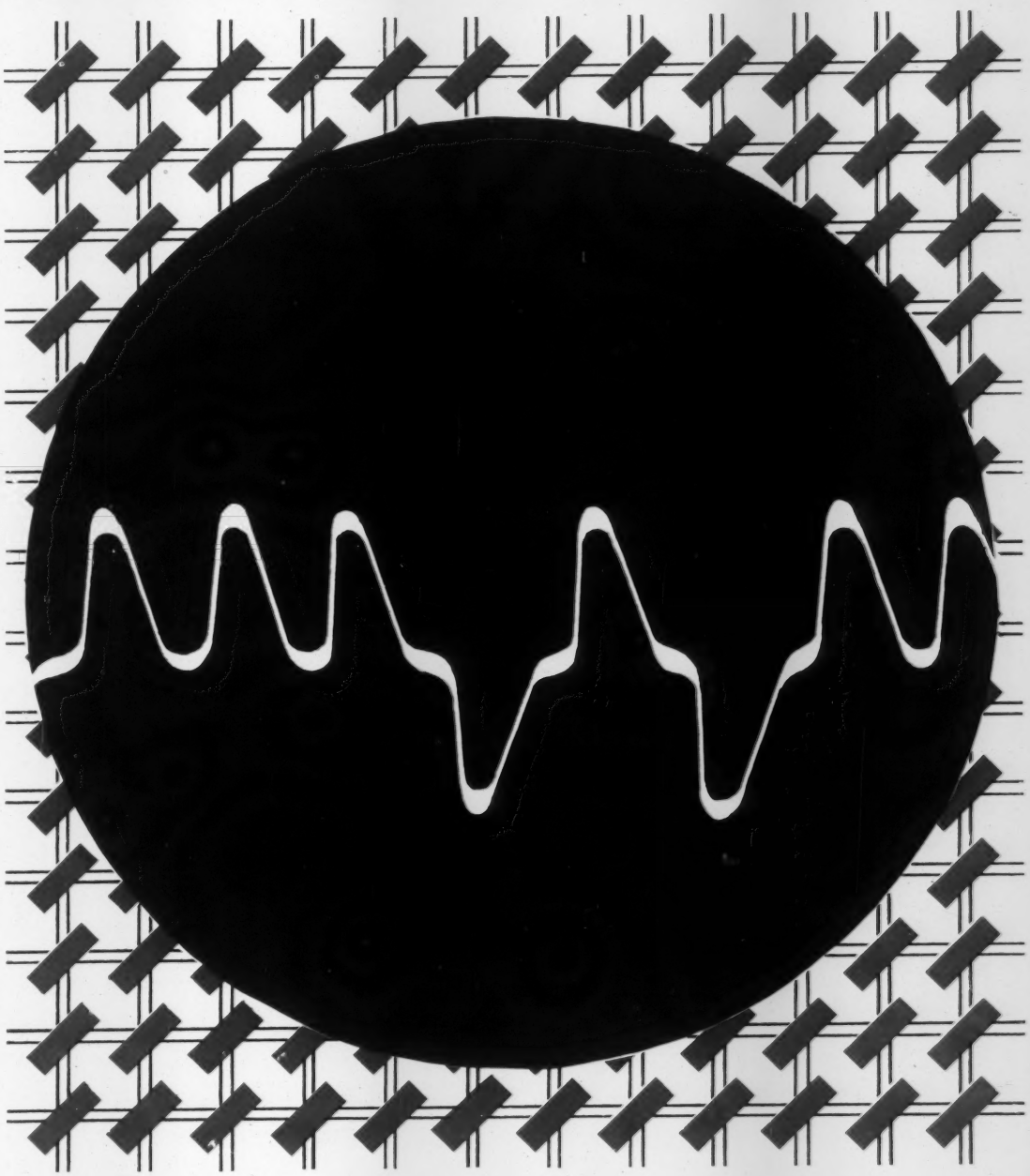
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: JOURNAL OF THE SCMA • PRECISION MEASUREMENTS ASSOCIATION • SIMULATION COUNCIL NEWSLETTER



AUGUST 1961

in this issue:

Magnetic Memory Cores 1427
Problems in Digital Recording 1430
Data Recording and Processing 1434
Statistical Techniques 1438
Interference and RFI 1443
Viscous Flow by Variable Area 1456

GPE Controls Model R790 **Electric Integrator** gives you direct integrated 6-digit read-out of any flow that can be represented by a D.C. electrical signal—with accuracy to within ½ of 1% over flow turndowns of as much as 10 to 1. Chart planimetering is eliminated. Unaffected by temperature changes from −30° to +130°F. Designed for use with GPE Controls linear signal electric flow transmitters, but suitable for many other applications as well.

Long-time accuracy and dependability assured by jeweled integrator motor, precision-made low friction gears and counter. Requires little panel space.

Write for descriptive literature

GPE Controls, Inc.

240 East Ontario Street • Chicago 11, Illinois

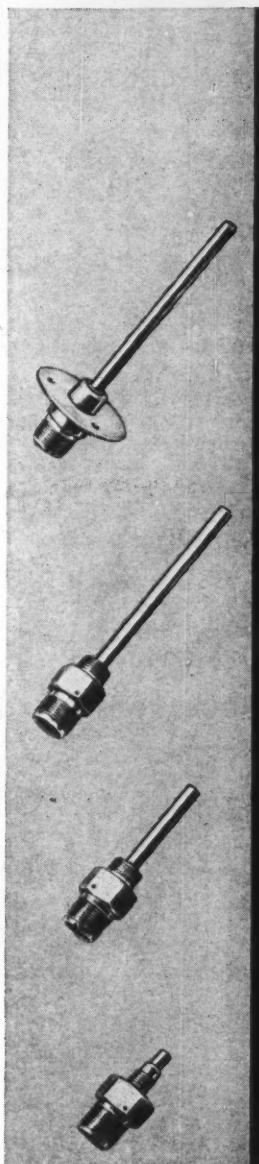
GPE Controls | GP

A Subsidiary of GENERAL PRECISION, inc.

CIRCLE 1 ON READER-SERVICE CARD

RESISTANCE *type* TEMPERATURE DETECTORS

By LEWIS



QUALIFIED, precisely-wound, individually calibrated units that meet or exceed the requirements of:

- MIL-B-8598 (ASG)
- MIL-T-25446B (USAF)
- MIL-B-7990A
- MIL-B-7258 (USAF)
- MIL-B-7370A
- MIL-B-5491A (Aer)

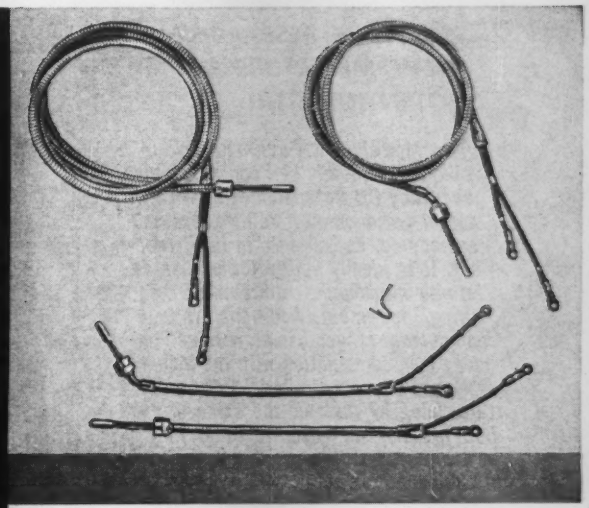
SPECIALLY DESIGNED temperature detectors for use in modern jet and piston-powered aircraft, made to the Airframe Manufacturer's specifications for sensing the temperatures of:

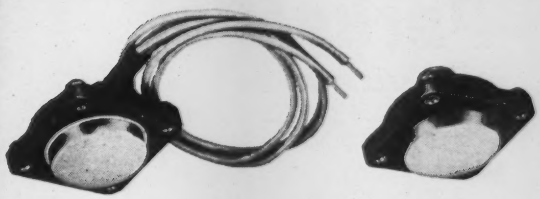
- FUEL TANKS
- FREON SYSTEMS
- HYDRAULIC SYSTEMS
- CYLINDER HEADS
- CABIN AIR
- ENGINE OIL
- FUEL AT ENGINES
- OUTSIDE AIR
- HEATER DUCTS
- RAM AIR
- GENERATOR-DRIVE UNITS

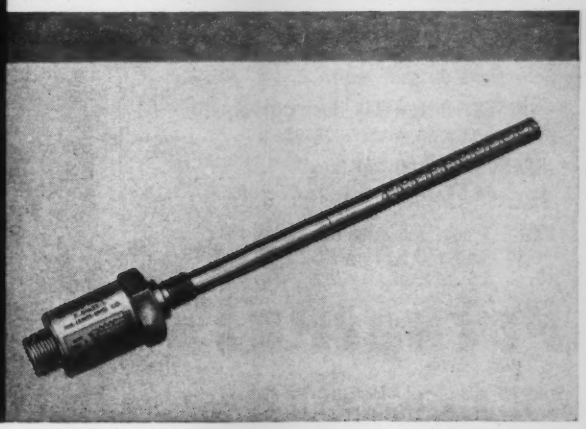
PLATINUM WOUND TRANSDUCERS for use in MISSILES, to measure the temperatures of:

- LIQUID OXYGEN
- COMBUSTION GAS
- HELIUM
- AIR

and other media to customer's specifications







FOR AIRCRAFT AND MISSILES

THE LEWIS ENGINEERING COMPANY

NAUGATUCK, CONNECTICUT

Specialists In Temperature Measurement

CIRCLE 2 ON READER-SERVICE CARD

***A new slant** on making high accuracy DC measurements conveniently and economically!*

The model PC
PocketPot*

(PHOTO ACTUAL SIZE)

SENSITIVE RESEARCH'S NEW MINIATURE DC POTENTIOMETER!

The Model PC "PocketPot," is a stable, completely self contained, high accuracy DC potentiometer, with internal galvanometer, reference standard source, and direct "in line" readout. It is ideally suited for use as an infinite impedance calibrator or measuring instrument. Additional voltage and current ranges can be obtained by using it in combination with the Model PC-1, a switch controlled, .05% accurate "plug in" unit of the same size. Both models, when used together, may be easily held and operated in the palm of the hand!*

PocketPot*

SPECIFICATIONS

ACCURACY: ± .05% of reading or ± .5 mv., whichever is greater.

RANGES: 0—5.099 v. When used with PC-1, 0-500 v. and 0-1 amp.

SENSITIVITY: Infinite resistance at null. When used with PC-1, 2,000 Ω/v.

RESOLUTION: Continuous, 1 mv. divisions on slide wire.

BATTERY OPERATED: Does not require an external power source.

READOUT: Direct "in line."

SIZE: 9" x 4¼" x 1¾". **WT:** 3 lbs.

PRICE: Model PC, $325.00; Model PC-1 $125.00. F.O.B., New Rochelle, N. Y.

PocketPot*

Write for additional information or contact your nearest SRIC sales representative.

*Copyright U.S.A. Patent Applied for.

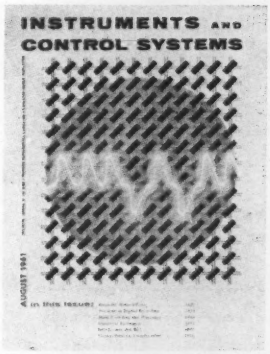
SENSITIVE RESEARCH
INSTRUMENT CORPORATION
NEW ROCHELLE, N. Y.

Symbol of Quality

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS



The magnetic core typifies the subject of major emphasis this month—digital techniques and data processing

VOLUME 34, NUMBER 8, AUGUST 1961

PRINT ORDER THIS MONTH 45,500

EDITORIAL

Ideas on the Undergraduate Curriculum 1425

DR. GRANINO A. KORN—The role of abstract models in engineering should be buttressed by physical experience

FEATURE ARTICLES

Magnetic Memory Cores 1427

MELVIN WHITMER—No. 8 in series of articles on storage devices covers introduction to magnetics, core properties, test procedure and basic wiring

Problems in Digital Recording 1430

L. A. ORMORD—How to find and avoid errors in recording digital signals on magnetic tape

Data Recording and Processing in Turbine Evaluation 1434

PAUL A. VERRETTE—Data recording center has monitoring equipment, analog computer, pneumatic scanner, digital computer, visual display, anemometry equipment, stress-strain equipment, and temperature logger

Statistical Techniques 1438

W. A. JASSON—Statistical techniques are needed in evaluating performance and accuracy, and in designing experiments and analyzing results

Journal of the Precision Measurements Association 1443

INTERFERENCE AND THE RFI METER by H. A. FAVORS, R. E. BLOOM, and R. J. FLEISCHER—RFI measurements demand consideration of the interference source, the RFI meter, and calibration factors

Standard on Shock and Vibration 1451

RAYMOND R. BOUCHE—New American Standards for the calibration of shock and vibration pickups

Process Control Systems 1453

FRED D. MARTON—Distillation column control by conventional pneumatic system; control system for inert gas generation; pelletizing-furnace blast-air temperature control; fractionator pressure control; protected remote pump

Richard Rimbach, Sr., Publisher

Richard Rimbach, Jr., Sales Manager

Milton H. Aronson, Editorial Director

Fred D. Marton, Managing Editor

Robert C. Nelson, Sr. Assoc. Editor

James Emge, Assoc. Editor

Josephine Martin, Assoc. Editor

John Moriarty, Eastern Editor

Robert B. Forest, Western Editor

John M. McLeod, Jr., Editor, Simulation Council Newsletter Section

John M. Quirk, Editor, Journal Southern California Meter Association

Robert E. Becko, Production Manager

Raymond C. E. Smith, Art Director

EXECUTIVE AND EDITORIAL OFFICES

Pittsburgh 12, Penna., 845 Ridge Ave., Fairfax 10161 or 19831

SUBSCRIPTION RATES

For One, Two, and Three Years

	One Year	Two Years	Three Years
United States, U.S. Possessions and Canada	$ 4.00	$ 7.00	$ 9.00
	(*Five Years* @ $10.00)		
Latin American	$ 6.00	$10.00	$14.00
All other countries	10.00	15.00	20.00

Position and company connection as well as products manufactured must be indicated in all subscription orders. Publisher reserves the right to refuse any subscription.

BPA ABC

Payments from outside the U.S.A. must be in the form of an International Money Order or check on a U.S. Bank.

For change of address, give old as well as new address, include postal zone number. If possible enclose address label from magazine. Please allow one month for change.

Postmaster: Please send Form 3579 to Instruments & Control Systems, 845 Ridge Ave., Pittsburgh 12, Pa.

OUT-OF-PRINT COPIES of *INSTRUMENTS & CONTROL SYSTEMS* are available in complete volumes as positive microfilm copies from University Microfilms, Inc., 313 N. First St., Ann Arbor, Michigan. Photostats of articles are also available from this source.

Instruments and Control Systems (including Instrument Manufacturing) published monthly by The Instruments Publishing Company, Inc. Office of publications, 1600 North Main Street, Pontiac, Illinois. Executive and Editorial Office, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania. Second-Class mail authorized at Pontiac, Illinois. Copyright 1961 by Instruments Publishing Company, Inc.

INSTRUMENTS AND CONTROL SYSTEMS

VOL. 34 NO. 8
AUGUST 1961

Variable-Area Meter for Viscous Service 1456

PHILIP O. DESMARAIS—Rotameters measure #6 Bunker C fuel-oil for 24 open hearths

Graphic Systems Techniques 1458

ALLEN DEVRISHIAN—Techniques for graphic displays for control systems

Remote Utility-Meter Reading 1462

A. BROTHMAN and E. W. LEWISON—An automatic remote meter-reading system for gas, water and electric utilities. Continues our telemetering series

Journal of the Southern California Meter Association 1465

CONTROLLING THE BIG SQUIRT by H. J. VAN HATTEN—Discusses control of the world's largest underground water injection system

The Universal Precision Dilatometer 1471

G. L. CUTLER—This dilatometer records thermal expansion automatically

Simulation Council Newsletter 1475

Southeastern S/C Meeting of 27 Jan. on Antenna Patterns, Computer Interconnection, and Blood Flow 1475
Rocky Mountain and Western S/C Joint Meeting of 10 March on IDA, Correlation, and Engineering 1477
Midwestern S/C Meeting of 13 March on Statistical Techniques and Transport Delays 1481
Analog Techniques by Robert Howe 1482
Letters 1484
SCI Activities 1486

OTHER REGULAR FEATURES

Letters to the Editor 1340
Events 1399
News 1365
Trends 1350
Stock Report 1352
Briefs 1370
Book Reviews 1345
New Instruments 1487
Inquiry Card 1503-1521
New Literature 1548
Product Index 1522
Searchlight Section 1552
Advertisers' Index 1554

INSTRUMENTS PUBLISHING COMPANY, publishers to the Instruments and Control Systems Industry with four publications:

INSTRUMENTS AND CONTROL SYSTEMS; INSTRUMENT & APPARATUS NEWS; MILITARY SYSTEMS DESIGN; MEDICAL ELECTRONIC NEWS

DISTRICT OFFICES

Richard Rimbach, Jr., Vice-President, Sales, New York, Murray Hill 8-0980
Boston 16, Mass., Harold H. Short, Jr., 269 Main St., 438-3982
Chicago 6, Ill., Harold W. Haskett, Madison Terminal Bldg., 9 South Clinton St., Central 6-8963
Clearwater, Florida, E. F. Nordstrom, 1651 Sherwood St., Clearwater 441-9033
Cleveland (Shaker Heights 22), Ohio, Max G. Bauer, 3310 Warrensville Center Rd., Wyoming 1-7145
Los Angeles 34, Calif., John Fahey, 2639 S. La Cienga Blvd., Upton 0-8442
New York 17, N. Y., Richard Rimbach, Jr., 525 Lexington Ave., Rm. 359, Murray Hill 8-0980
Pittsburgh 12, Penna., Robert Brandegee, 845 Ridge Ave., Fairfax 10161
Philadelphia 4, Pa., Robert V. Frey, Suite 100, 101 N. 33rd St., Evergreen 2-3878
San Francisco 11, Calif., Charles Clark, 420 Market St., Douglas 2-3899
St. Louis 1, Mo., Steve Wright, Fred Wright Co., Room 416, 4 N. 8th St., Chestnut 1-1965
London, W. C. 2 England, John C. N. Hughes, T. C. Scott & Son Ltd., No. 1 Clement's Inn, Holborn 4743.

POST ELECTRONIC PRODUCTS and CONTROL SYSTEMS

ASSURE:

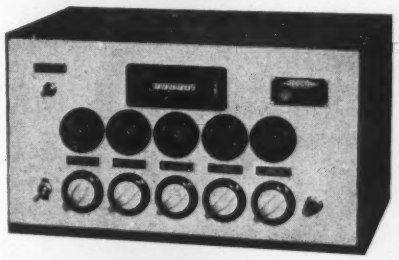
RELIABILITY • ACCURACY
LOW MAINTENANCE • PRODUCTION CONTROL

Post's *proven* electronic counters and control systems are in widespread use throughout industry. Serving such diverse needs as batch counting, measuring, sensing or machine control. Post electronic products are ideal production aids.

Note these examples of Post's broad line of Electronic Products . . .

COUNTERS

SD-1T Outmodes mechanical counters. Will operate at speeds up to 100 units per second. Single 'count' registers on visual totalizer as each 10th. item breaks beam. Note: 12 place tube available for counting dozens or gross lots.



P-5 Preset counting of any desired 'batch' — 1-100,000 units. Other models available for 10,000 or 1,000,000 range. Direct 'batch' readout on all models from totalizer . . . quantity less than 'batch' shown directly on tube face (s).

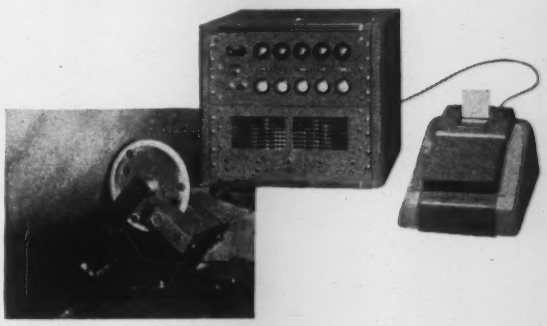
PW-5 PRESET Counter with BUILT-IN WARNING SYSTEM. Model shown will 'batch' count 1-100,000 units (inclusive) and warning selection dials may be set to energize a secondary control circuit, i.e., 'Batch' count desired 5000 . . . warning count desired 4900. When warning count reached, impulse may be given to flash light, operate solenoids for opening or closing feed gates, etc.

SENSING DEVICES

H-21-C A miniature, all purpose photohead. Ideal for limited space application. 'Head' not much longer than standard paper clip. Exciter lamp life 5000 hours. Utilizes photosensitive semi-conductor cell.

MH-2-P A new, compact magnetic switch in neat epoxy resin shell. . . . Magnetically operated as sensing device, the MH-2-P is capable of speeds up to 100 cycles per second — long life — no "bounce".

CONTROL SYSTEMS



LF-1A Lineal footage measurement, electronically . . . Capable of length measuring continuous production items, i.e., paper, wire, rope, ribbon, etc.
Features visual and printed readout.

**Representatives throughout the United States*
Request product literature today.

POST

ELECTRONIC PRODUCTS

Division of Reid Brothers Company, Inc.
12 LOTHROP STREET, BEVERLY, MASSACHUSETTS

Your special problems are earnestly requested!

Note: Complete line of production line counters available.

CIRCLE 4 ON READER-SERVICE CARD

	SD-1T
	P-5
	PW-5
	H-21-C
	MH-2-P
	LF-1A

Please send me product literature on the following:

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

To discover what you believe is possible...

CIRCLE 5 ON READER-SERVICE CARD

You're so sure the answer's there. From what you already know... from what's been proved so far, it has to be. But that's when your hardest work begins. To give your answer precise shape and substance. To prove it. And use it to move to the next step. At some point during your quest, there's a good chance CEC can come in and help. Because this is exactly what CEC men do for a living—find the means and build the instruments to measure, record, and analyze some of the things that can help supply you with the answer you must have. Are you in the middle of such an answer search right now? Or looking for a starting point on a problem? Call in a man from the CEC sales and service office nearest you. It's worth a try.

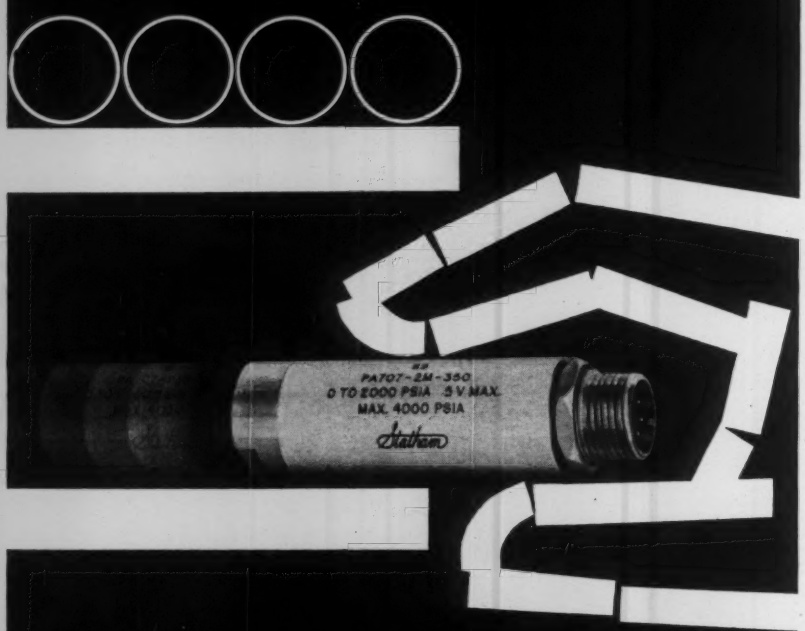
CEC

CONSOLIDATED ELECTRODYNAMICS

PASADENA, CALIFORNIA • A SUBSIDIARY OF BELL & HOWELL

DATA RECORDERS DIVISION • ANALYTICAL & CONTROL DIVISION • TRANSDUCER DIVISION • CONSOLIDATED SYSTEMS CORP. • CONSOLIDATED VACUUM CORP.

NOW AVAILABLE FROM STOCK!!!



Statham's Multi-purpose P707 Pressure Transducers

Statham's Model P707 series of rugged, general purpose pressure transducers are now available for immediate delivery! The compact, lightweight P707 has been designed to withstand the stringent environmental conditions encountered in high performance aircraft, space probes, and ballistic missiles.

This Zero-length/dimensionless pressure transducer features a wide variety of ranges, low sensitivity to acceleration, and excellent thermal performance without sacrifice in frequency response or in non-linearity and hysteresis characteristics. Available for measurement of absolute and gage pressures from 0-5 psi through 0-5,000 psi.

For complete data on the P707 contact the Statham sales office in your area or write to:

Statham STRAIN GAGE DIVISION

Statham Instruments, Inc., 12401 W. Olympic Blvd.
Los Angeles 64, Calif. GRanite 8-0361 TWX West Los Angeles CAL 6602

ICS LETTERS TO THE EDITOR

Editor, I&CS:

Mr. Nanigian's comment (Swaged MgO Thermocouples, May *I&CS*) that long life for thermocouples is not always desired is contrary to the majority of thermocouple users. The insulation spacing down to 0.004″ is quite correct, and with SPS (single pass swaging) presents no problem whatsoever. In fact, at 200 volts per mil applied, the material can easily withstand 800 volts. No shorts can possibly occur at the cold junction, since the rock-hard ceramic positively eliminates wire contacts. We see no appreciable increase in response speed with smaller-than-standard wires, since in a standard grounded junction construction, the weld and material are the major factors.

In the recent paper ORNL-2773 by Potts & McElroy of Oak Ridge, the fact is reemphasized that small diameter wires, as recommended by Mr. Nanigian, show increasing loss of calibration stability to an unusable figure. The cost of larger wire in base-metal calibrations is negligible.

The cost of the thermocouple (mentioned several times) is actually of small importance in comparison with its function. The cost relationship may be compared with the reasoning that premium quality tire cord and rubber makes a tire cost "too high." It's all a measure of personal analysis and choice.

Earle C. Smith, President
Smith Thermotronics, Inc.
Formerly E. C. Smith Mfg. Co.
Forrest and Hector Streets
Conshohocken, Pa.

Editor, Simulation Council Newsletter:

I have read with great interest your article on the M.A.C. (McLeod Aerating Cardiac) pump. If this unit can adequately oxygenate blood, and does not require a tremendous prime, it should be an extremely valuable apparatus. If you have other information regarding this pump I would appreciate having the opportunity to review it.

George Margolis, M.D.
Chairman, Department of Pathology
Medical College of Virginia
Richmond, Virginia

← CIRCLE 6 ON READER-SERVICE CARD

Editor, I&CS:

Inspection of cherries for pit removal can be done on two bases: radiation transparency and density. The density method is based upon fact that the bulk density of a cherry decreases when the pit is removed. The simplest way of measuring density in this case is, I believe, to measure mass and volume separately. Volume can be measured by having a cherry interrupt a light beam. A photocell, acting as an exposure meter, produces a signal related to the volume of the cherry. Weighing can be carried out quickly by measuring the strain in, or displacement of, a cantilever beam. Unlike ordinary scales, displacements in such an arrangement are microscopic and equilibrium is quickly attained. The electrical signals related to mass and volume are then combined to yield a signal related to density. This density signal controls diverting equipment which separates pitted from unpitted cherries.

The radiation transparency method is based upon the fact that a pitted cherry is more transparent than one in which the pit is still present. Either infrared or gamma radiation can be used. A detector measures transparency and activates diverting equipment when a relatively opaque cherry is observed.

The question of counting cherries mixed with syrup is difficult. The weight of the cherries can be determined within 5% by weighing the mixture, measuring the volume of the mixture, measuring the density of the cherries, and measuring the density of the syrup. The pertinent equations are not presented, as this approach may not meet objectives of accuracy, particularly if the number of cherries is needed, as opposed to the total weight of the cherries.

Sincerely yours,
J. N. Gadel
Consulting Physicist
East Orange, N. J.

Editor, I&CS:

In *I&CS* Trends, lead item in the May issue, you refer to "Armour Research Foundation" of "University of Illinois." This should be "Illinois Institute of Technology." IIT was formed from Armour Institute and Lewis Institute of Chicago in '42 and has no connection with University of Illinois.

Anthony Hitzenhammer (IIT '48)
P. O. Box 17162
San Diego 17, *Calif.*

hays

RAMBLINGS ON INSTRUMENTATION

Va-a-room!

(An explosive case history)

In an effort to inject a documentary note into our advertising, we are asking our field force to send us good, solid case histories of some of our new products in use. The first to respond was good old Melvin, our lovable representative in the southeastern Northwest territory. (Or is it the other way around? . . . we never can remember.) Anyway, here is the transcript of his tape recorded, on-the-spot interview with Potherington P. Potts, president of the Little David Dynamite Company of Bad Guess, Idaho, one of many industrial giants we serve.

"Mr. Potts, I'm here to get the straight performance facts about your new Hays 632C Low Range Oxygen Analyzer. Now first, why did you buy a beautiful, sophisticated instrument like this in the first place? Was it because of its fully transistorized circuitry?"

"Naw"

"Because it has printed circuits with plug-in, pull-out interchangeable range cards for easy-as-pie servicing?"

"Naw"

"Because it is unaffected by hydrogen and other common components of the carrier gas?"

"Naw"

"Come on now, Mr. Potts, why *did* you buy the Hays Low Range Oxygen Analyzer?"

"To tell the truth, I figured that nice pearly gray finish would go real well with the walls in the plant. Got any more dumb questions, boy?"

"Er, yes, I mean no. I mean . . . tell me, Mr. Potts, what is this big barny room we're in now?"

"This is Final Assembly, son. The dynamite comes in on that conveyor belt there and these men stuff it into sticks, slap in a fuse and there you are."

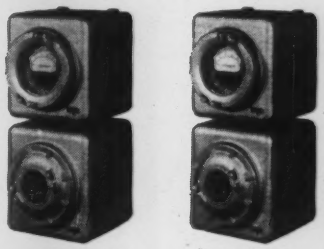
"Mr. Potts, I can't refrain from commenting on the fact that all these men stuffing dynamite are smoking like crazy. Isn't that a mite . . . er, unusual? I mean in a *dynamite* factory yet!"

"Son, don't you know this low range O_2 Analyzer is *explosion-proof?*"

"Well of course, but . . ."

"Son, until we got that analyzer the boys had to sneak outside for a smoke. The loss in production was fantastic. Fantastic, I say!"

NEW EXPLOSION-PROOF LOW RANGE
Oxygen Analyzer 632C



BEFORE AFTER

"Yes, but . . ."

"Why, I figure that just by saving us the time lost in smoke breaks, the Hays Low Range O_2 Analyzer will pay for itself in 179 years! Think of that, son."

"Mr. Potts, I don't think you quite understood about the explosion-proof bit. You see . . ."

"Son, you talk too much. Buying that explosion-proof low range O_2 analyzer was the smartest thing I've done for this company. Here, boy, have a cigar."

"But . . ."

"Son, with 0-1 to 0-3% standard range with 0-10% coarse setting available for process startups, the Hays Low Range Oxygen Analyzer is . . . here, let me give you a light, boy."

"But . . ."

"You were saying, boy?"

"Mr. Potts, even though your new analyzer is explosion-proof I don't think I'd throw that match over . . ."

That, unfortunately, is the end of the tape. We will dutifully report any further documentary details on this interesting case history as they are received. Meanwhile may we suggest that you send for our little treatise numbered B632C which gives further information on this advanced instrument. And, which, we hope will clear up any possible misunderstanding of what we mean by "explosion-proof." Guess you just can't take *anything* for granted.

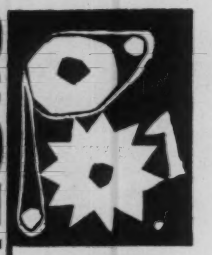
(We *may* have an opening for a man in our southeastern Northerwest territory. Check if interested.)

Phil A. Sprague
President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

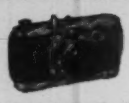
CIRCLE 7 ON READER-SERVICE CARD

PHOTOGRAPHIC AUTOMATION



ROBOT 35mm CAMERA—NUCLEUS OF A COMPLETE ELECTRO-AUTOMATIC RECORDING SYSTEM

ROBOT ROYAL S/Sa: 24 x 36mm, 24 x 24mm or 18 x 24mm frames; with coupled range/viewfinder (lenses from 30mm to 400mm); automatic one-by-one shots or Kinographic Sequence for bursts of 5-6 frames per second.



ROBOT RECORDER: 24 x 36mm, 24 x 24mm, 18 x 24mm or 6 x 24mm frames; without range/viewfinder. OPTIONAL: rewind knob, sequence release, reticle, reflex system for double exposing second 8 x 8mm image.

ROBOT STAR II: 24 x 24mm frames; with lumiframe viewfinder (lenses from 30mm to 150mm); single motor for 20 exposures or double motor for up to 55 exposures without rewinding.

ROBOT COMPLETE ELECTRO-AUTOMATIC RECORDING SYSTEM: Royal or Recorder Camera w/30 or 200 ft. magazine; electric booster motor; camera holder; remote release; angle bracket; transformer-rectifier; intervalometer (timer) from ¼ sec. to 24 hours.

ROBOT—THE TRADEMARK OF PHOTOGRAPHIC AUTOMATION

See your franchised ROBOT dealer or write for free illustrated brochure ICR-8.

karl heitz

480 LEXINGTON AVE., NEW YORK 17 • YUkon 6-4920

CIRCLE 8 ON READER-SERVICE CARD

GÜBELMAN

CHARTS PAPERS·INKS

for Recording Instruments

We offer to the instrument maker

CHARTS
for all methods of recording, including Pen, Ball Point, Electrical, Thermal and Pressure, in roll or flat form.

INKS
for Diazo and general use.

PAPERS
Heat, pressure and electrical sensitive papers of all types. Sole suppliers of Nashua's Heatrace*, Prestrace*, Electrace* Charts.

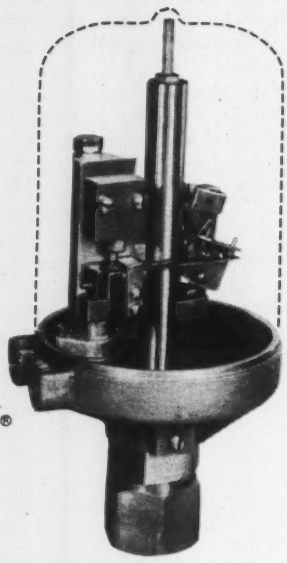
*TRADEMARK

GUBELMAN CHARTS

DIV. OF NASHUA CORPORATION

100-6 E. KINNEY ST., NEWARK 5, N. J.

NEW, non-bleed pneumatic liquid level controller



By

MAGNETROL®

model J-2

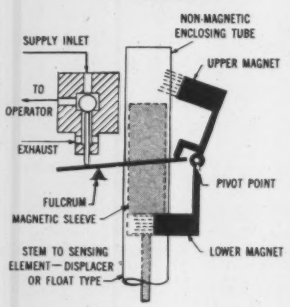
DEPENDABLE AS THE PULL OF A MAGNET

wherever you need

- **Ultra High Vibration and Corrosion Resistance—Chemical, Petrochemical and Petroleum**
- **Operation from Air, Wellhead or Other Gases**
- **Snap-Acting, Magnet-Controlled Actuation**
- **High-Speed Response for Liquid Metering and Rapid Cycling Processes**
- **Pressures to 40 psig Standard, to 100 psig on Application**

In the Magnetrol J-2 you get all the benefits of Magnetrol's unique magnetic operating principle applied to pneumatic ON-OFF, single-stage control of liquid levels . . . Dual magnets position a 3-way stainless steel valve—provide snap-action and positive holding even under heavy vibration. All metal operating parts are of stainless steel or aluminum for maximum corrosion resistance and are enclosed in a splash-proof housing. Suitable for all common temperatures and liquids. J-2 Switch Mechanism can be used with practically all Magnetrol units to provide reliable pneumatic control.

HOW IT WORKS



Magnetic sleeve, inside nonmagnetic enclosing tube, rises or falls with changing liquid levels. Attracting sleeve is **always** in field of upper or lower magnet. (Shown, low-level position.) Lower magnet is "pulled" in, supply inlet is open and air or gas flows to operator. On rising level, sleeve attracts upper magnet. In this position lever and fulcrum arrangement cuts off supply and allows air or gas trapped between operator and valve to exhaust to atmosphere. Reverse action can be provided by simple adjustment in the field.

Mail coupon today for full details—just attach to your letterhead.

MAGNETROL, Inc.

5326 Belmont Road, Downers Grove, Illinois

20

Please send Catalog data and full information on Magnetrol J-2 pneumatic Liquid Level Controller.

Name_____

CIRCLE 9 ON READER-SERVICE CARD

Editor, I&CS:

I note in *Instruments and Control Systems* that you have an inquiry (A-6101 Feb., I&CS) regarding an automatic float control system for 190 degree trichlorethylene.

The company I am presently working for, about two and one-half years ago, had need of reclaiming tri-chlor. They needed pure tri-chlor in their process and decided to distill their own as the commercial grade available was not pure enough for their use. They then ordered a Stokes Water Still with assurance by the supplier that it could be used for this purpose. On arrival of this still and with subsequent hook-up according to directions, it was found that it would not operate satisfactorily as a tri-chlor still.

I had to resort to remodeling this particular still into an automatic operation as the output of this still was only two gallons per hour and the company had need of ten gallons in a four-hour period at the beginning of the work day. This system was only in the prototype stage, but has been operating continuously since that time until today, with very little maintenance and no new parts.

If you are interested in the possibilities of this system, and would care to write me as to your system and what you are doing, I would be happy to give you the benefit of my experience in this matter.

Owen F. Griffith
Spring City, Pa.

The man with the problem has been informed. Thanks.

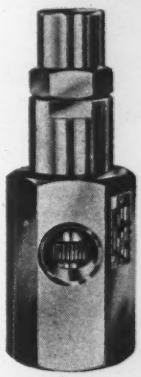
Editor, I&CS:

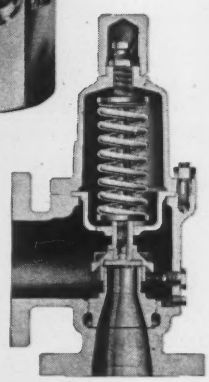
Our February, 1960 issue of *Instruments & Control Systems* is missing and thus the Digital Instrumentation series is incomplete by the first article. We hope that a back issue of that date or tear sheets are available. If so, would you kindly send this to us and let us know the charges. Our check will be forwarded promptly.

While we have the opportunity, we would like to tell you how much we enjoy your publication. The articles are very useful and are a good source for ideas. The advertisements and briefs are particularly valuable for keeping us informed.

W. L. Atwood
Electrical Engineer
Warren, Ohio

The Symbolic Logic series began in November, 1955! It will be available in book form at its conclusion—in about six more months.





From the Near East to our own Far West . . . the name Farris on safety-relief valves has been a standard synonym for safety since 1943. The patented design features on all Farris full-nozzle valves combine to offer the ideal concept of a trouble-free, 100% safe safety-relief valve for every application.

SERIES 2600

The most popular top-guided, self-aligning, safety-relief valve for process piping service. Maximum pressure, 150 to 2500 psig, RF/RJ. Plain or Lever types. Standard or BalanSeal bellows construction.

SERIES 2740

A cast-steel relief valve of simplified design for use where extreme blow down accuracy is not essential, but where durability, compactness are. Pressures to 3500 psig at 450°F; 2000 psig at 800°F. Sizes ½" to 2".

SERIES 2745

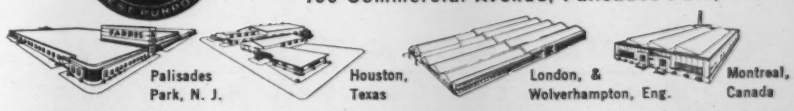
An extremely rugged, compact, high pressure bar stock nozzle valve. Internal parts stainless steel. Adjustable blow down; flat seat; self-aligning stem and disc. Pressure to 10,000 psig. Sizes ½", ¾", 1".

SERIES 2950

A cast iron safety-relief valve including most of the exclusive Farris features found in the Series 2600. Max. pressure, 250 psig at 450°F, 400 psig at 150°F. Plain cap, open lever or packed lever types.

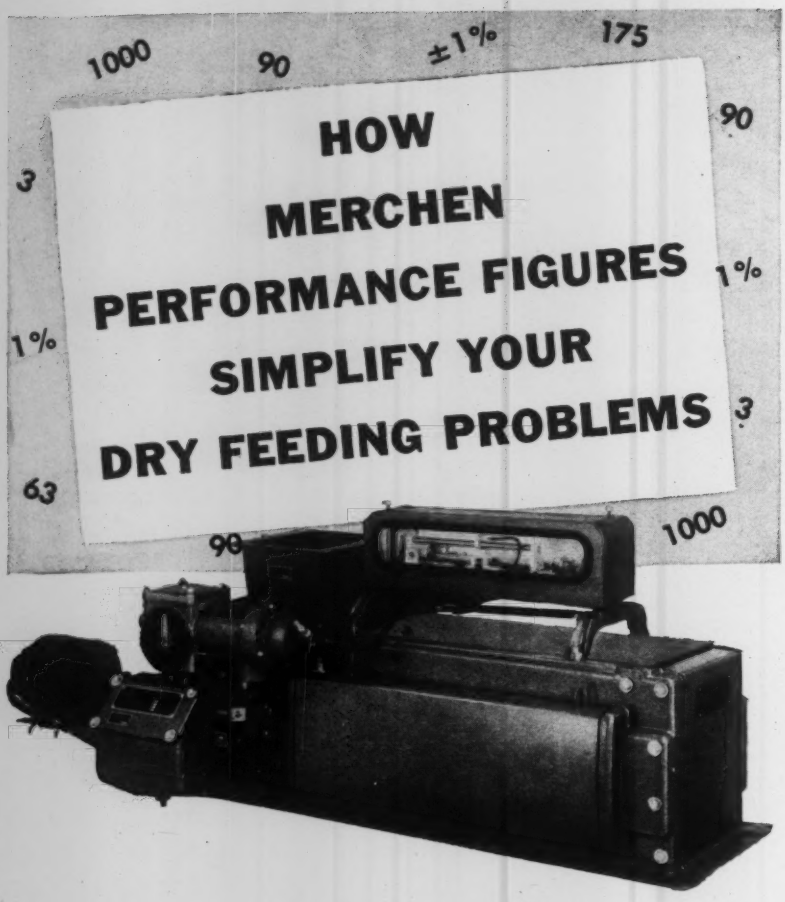
Replace with FARRIS . . . Standardized face to face dimensions

Farris® ENGINEERING CORP.
706 Commercial Avenue, Palisades Park, N.J.



AFFILIATES: Farris Combustion Controls Corp. • Farris Flexible Valve Corp. • Farris Universal Machine Corp. • Farris Industries Canada, Ltd., Longueuil (Montreal) • Farris Engineering Ltd., London, England • Midland Inudstries Ltd., Wolverhampton, England

CIRCLE 13 ON READER-SERVICE CARD



3 lb. to 90 tons an hour. That's the span of Merchen Feeder capacity. 1% of set rate and 1000:1. That's its accuracy and range. Coal, pigments, wheat, carbon, sawdust. These are some of the 175 common, dry, free-flowing materials a Merchen feeds with ease.

These figures tell the story of a Merchen's versatility. Whether you blend continuously or by batch, the Wallace & Tiernan Merchen Feeder simplifies your entire process. Use it as a straight gravimetric feeder, as a master proportioning other ingredients in the process, or as a slave with instant response to external pneumatic signals.

The Merchen responds to a change of just one ounce in a 63-pound belt load. That's because the Merchen weighs only actual material—never feeder components. This means constant delivery with minute-to-minute accuracy of ±1%. Corrosion-resistant construction means long, trouble-free life. And the Merchen's compact size—less than 3 ft. x 5 ft. for the largest model—lets it fit almost anywhere.

Information from Dept. M-60.48.

WALLACE & TIERNAN INC.
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 11 ON READER-SERVICE CARD

Editor, I&CS:

I am writing in regard to Mr. John McLeod and the "Mac Pump."

I have spent most of my professional life in the general field of research in extracorporeal circulation, or "heart-lung machines." The first patient undergoing open-heart surgery in the West was done using a machine I designed and operated. Our group here has currently designed and is using what we believe to be the most advanced perfusion system yet developed and we maintain, I believe, the largest case-load of open-heart surgery in California.

One of the great difficulties in medical engineering has traditionally been the difficulty of bridging the communication gap between biological problem and engineering problem. The literature is full of the results of fine engineering solving the wrong problem, while fine biological work is held up by poor engineering.

I came across the work of Mr. McLeod almost by accident and have given fascinated attention for the following reasons: Here is an instance in which an engineer solved the right problem in a simple way without introducing new problems, and with an inherently reliable system. It is hard to overstate how much I admire his solution to the heart-lung machine problem. It is simple, elegant, inexpensive and reliable; it avoids many of the difficulties inherent in other currently available perfusion machines.

Our group invited Mr. McLeod to spend a week in our laboratories so that we could have an opportunity of working with his aparatus. We were able to put it through quite extensive tests both "in vitro" and in vivo," through all of which it performed excellently. Without going into details (they are separately available), two perfusions in animals which we were able to carry out went very well. Both animals did extremely well through rather long perfusions and were long-term survivors.

While our own perfusion system or "heart-lung machine," which can be duplicated for a cost of about $12,500, can do a few things which Mr. McLeod's cannot, Mr. McLeod's system, which can be reproduced for a cost of a few hundred dollars, seems to me capable of meeting all of the requirements of most perfusions safely, reasonably cheap, and simply. Our work with it also makes us suspect that it may be uniquely useful in a special field of its own for the following reasons: For long term use of heart-lung machines, when the perfusion may be continues for several days (for instance to treat acute

coronary heart disease) it will be necessary to have an apparatus which is particularly gentle to the blood. In fact, development of an apparatus gentle enough has been the difficulty in the experimental work in this field. One of the inherent factors in Mr. McLeod's pumping and oxygenating system is that it is essentially non-traumatic. It is the only pump-oxygenator I know of without valves, without serious areas of turbulance, and without jet-regions which break up red cells. It may very well have important promise in adaptation for very long perfusions.

I hope that Mr. McLeod will be able to find continued support for the development of his pump-oxygenator. It seems to me to be immediately useful, almost without change, in the experimental laboratory, as an inexpensive but high-quality pump-oxygenator. (It is, for instance, almost as cheap as a "bubbler-oxygenator," but has the greatly expanded margin of safety of the "filming" systems without their usual great expense). With very little final engineering it should be useful for thoracic surgery in patients with congenital heart disease. Finally, of all pump-oxygenator systems I have studied, it seems to me to hold the most promise as a practical solution to the stringent requirements for long-term perfusions for supportive therapy (during which the heart-lung machine may be called on to run for several days).

Its advantages include inherent simplicity, relatively small size, and the disposability of its oxygenating system—the tubing coils. This problem of disposability is a most important one because of the toxicity of the pyrogens left behind after an apparatus is used once.

The Convair-Astronautics Con-Trib-Club Committee should be highly commended for its role in the development of this highly original apparatus. It was an imaginative and original thing to do.

John J. Osborn, M.D.
Secretary-Treasurer
Associate Clinical Professor of Pediatrics
Stanford Medical School and Research
Associate in Cardiovascular Surgery

Editor, I&CS:

Your publication of my article last year (Centrifugal Flowmeter, Feb., 1960) brought me some very interesting and enjoyable contacts.

John T. Cortelyou
Los Angeles, Calif.

READ

differential or gauge pressure *quickly... accurately... reliably*

Wallace & Tiernan Aneroid Dial Indicators give you fast response, high sensitivity, reliable accuracy.

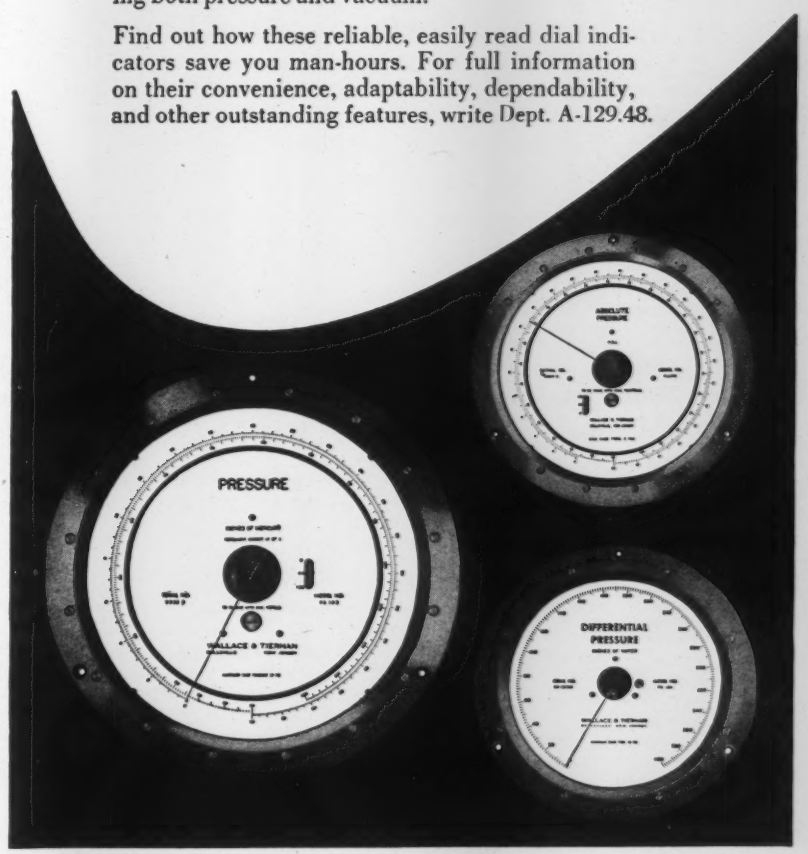
Whether you're in testing, manufacture, or research, there's a W&T Dial Indicator that's ideal over a wide range of differential or gauge pressures.

A W&T Aneroid Dial Indicator guarantees you:

- ★ Accuracy 0.1% to 0.33%
- ★ Sensitivity 0.01% to 0.2%
- ★ Range 0-10″ H_2O to 0-500 p.s.i.g.
- ★ Light weight, small size
- ★ Custom-calibrated dial
- ★ No corrections

W&T Aneroid Dial Indicators are also furnished as compound gauges with zero center for measuring both pressure and vacuum.

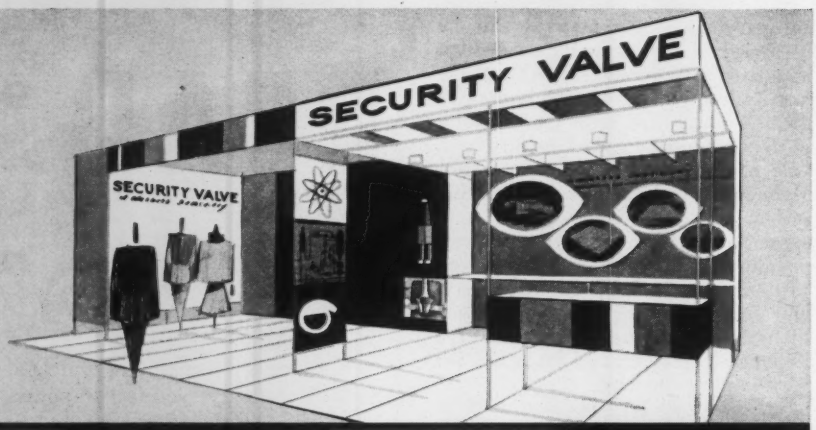
Find out how these reliable, easily read dial indicators save you man-hours. For full information on their convenience, adaptability, dependability, and other outstanding features, write Dept. A-129.48.



WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

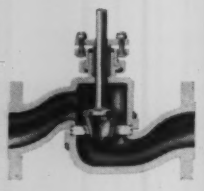
CIRCLE 12 ON READER-SERVICE CARD

SEE
SECURITY'S
NEW VALVE LINE
'61 I.S.A. SHOW
LOS ANGELES
•
BOOTH 406



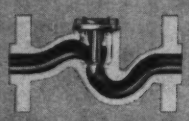
LIQUID HYDROGEN

Featuring unique design and employing a Y-BODY with vacuum jacketing, the LIQUID HYDROGEN control valve represents the foremost advancement in cryogenic control. This valve has an extremely large CV with minimum pressure drop, heat losses are the lowest attainable. These LH_2 valves may be furnished with expansion bellows on the jacketing in all sizes and ratings.



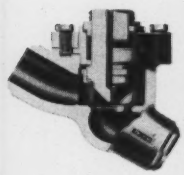
SPLIT BODY

Security's split body valve provides the user with maximum versatility. Having many of the advantages of solid body types, this valve features high lift, percentage, linear of on-off characteristics and dead tight shut-off. Fluids are handled over a very wide range of temperatures and pressures. Conversion to angle, corner or 3 way pattern, and separable flange construction provides greater flexibility with economy.



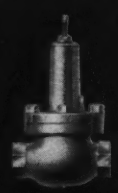
SOLID BODY

For rigorous applications, this single piece SOLID BODY valve is the answer. An extended range of applications, including radioactive service, are possible within its broad temperature variation of —450°F to +1500°F. Servicing of the inner valve without line removal minimizes maintenance costs. Solid body valves lend themselves to thermal or cryogenic jacketing or seal welding with equal facility.



Y-BODY

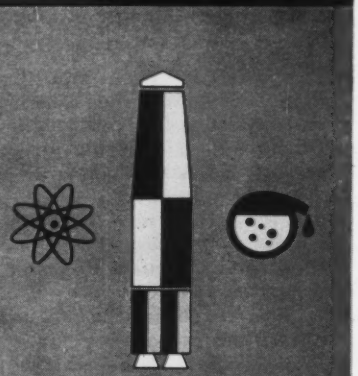
For the user requiring high capacity and large flow rates, nothing does the job like Security's Y-BODY valve. Design features include reduced inner valve turbulence and extremely high CV. Additional engineering design details include bubble tight shut-off, soft or hard seat construction, over a wide range of temperatures and in all ASA pressure classes.



AUTOMATIC SHUT-OFF

The full flow valves are designed to provide automatic safety in gas transmission and distribution. Up stream pressures are sensed and when line pressure is increased or decreased from a pre-determined setting, the valve automatically closes. Available in all ASA ratings thru 2500 lbs. Special models available to 35,000 lbs.

SECURITY VALVE COMPANY designs, develops and manufactures one of the most complete lines of industrial and military control valves available from a single source . . . In missile ground support and propellant loading of cryogenic materials, the Security developed LIQUID HYDROGEN VALVES represent but a single element in the broad range of outstanding technical capabilities . . . In industrial control valves, the broadest range of sizes, pressures, materials and accessories conforming to ASA specifications . . . In gas transmission and distribution, the finest quality shut-off valves provide "AUTOMATIC SAFETY." Security automatic safety valves are STANDARD for over-pressure protection devices in the gas industry.



SECURITY VALVE

SECURITY VALVE COMPANY
A SUBSIDIARY OF MENASCO MFG. CO.
909 EL CENTRO STREET
SO. PASADENA • CALIFORNIA

CIRCLE 15 ON READER-SERVICE CARD

ICS BOOKS

For more information on these books, or for publisher's book list circle number on reader-service card.

Flow Meter Engineering Handbook, third edition, by Charles F. Cusick, Brown Instruments Division of Minneapolis-Honeywell Regulator Company, Wayne & Windrim Aves., Phila. 44, Pa., 170 pp., clothbound $7.00. New edition has basic flow calculations rearranged for easy reference and expanded to include primary measuring devices other than orifice plates. Includes numerous schematic diagrams, graphs, charts, tables, and other data, contains separate chapters on steam, liquid and gas flow calculations, each with all data necessary to calculate or check an orifice plate installation.

CIRCLE 206 ON READER-SERVICE CARD

Semiconductors and Transistors by Alexander Schure, [c1961] John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y., 144 pp., 8½" paperbound $2.90. Volume in the Electronic Technology Series discusses and evaluates theory and characteristics of semi-conductors and transistors. Considerable attention is given to basic design procedures in transistor amplifiers.

CIRCLE 433 ON READER-SERVICE CARD

Weight-Strength Analysis of Aircraft Structures by F. R. Shanley, [c1960] Dover Publications, 180 Varick St., New York 14, N. Y., 404 pp., 8¼", paperbound $2.45. Scientifically sound methods of analyzing and predicting the structural weight of aircraft and missiles are discussed. Valuable for designer, stress analyst, etc.

CIRCLE 207 ON READER-SERVICE CARD

Introduction to Laplace Transforms for Radio and Electronic Engineers, by W. D. Day [c1960], Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y. 183 pp., 8½", clothbound, $5.50. "Written by a radio engineer for radio engineers" this book uses practical approach of use of mathemetics to solve practical problems. Gives the student the facility of using transforms to investigate transient conditions. Transforms will be found much easier to handle than differential equations.

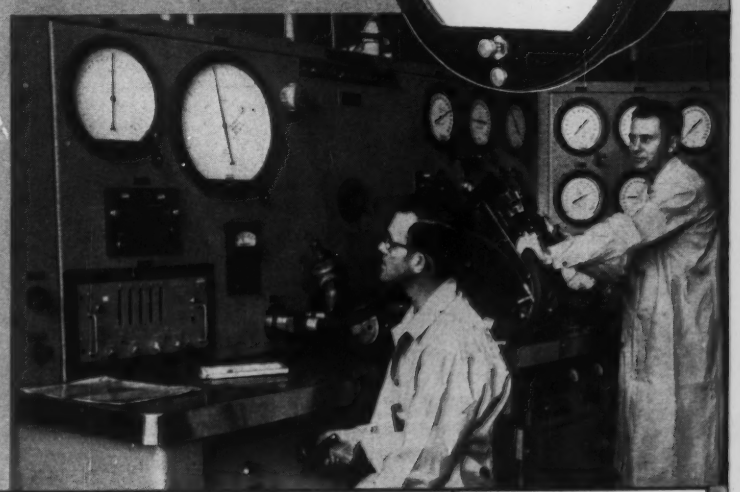
CIRCLE 208 ON READER-SERVICE CARD

HEISE GAUGES

Where ACCURACY *is Paramount*

Aircraft and missile programs, vital to national defense, are dependent upon reliable laboratory data in the design of power plants and their components.

Only instruments of the highest caliber are selected for use on research projects in this critical field and, where hydraulic pressures are involved, Heise Gauges are invariably specified.



ACCURACY	HYSTERESIS	CAPACITY
0.1 of 1%	0.1 of 1%	0-100,000 p.s.i.

This Hydraulic Test Stand, manufactured by the Test Equipment Division of Consolidated Diesel Corporation and featuring Heise Gauges, is typical of the aircraft and missile ground support equipment that goes into the defense effort.

Dial Sizes	FULL SCALE READING (P.S.I.)						
	0-15 to 0-5,000 inclusive	Over 0-5,000 and including 0-20,000	Over 0-20,000 and including 0-30,000	0 to 40,000	0 to 50,000	0 to 75,000	0 to 100,000
8½"	$183.50	$205.50	$238.50				
12"	$209.50	$231.50	$264.50	$275.50	$286.50	$336.50	$386.50
16"	$255.50	$277.50	$310.50	$321.50	$332.50	$382.50	$432.50

DELIVERY — 2 WEEKS FOR MOST RANGES — PRICE F.O.B. NEWTOWN

Request Catalog for SPECIAL FEATURES

HEISE BOURDON TUBE COMPANY, INC.

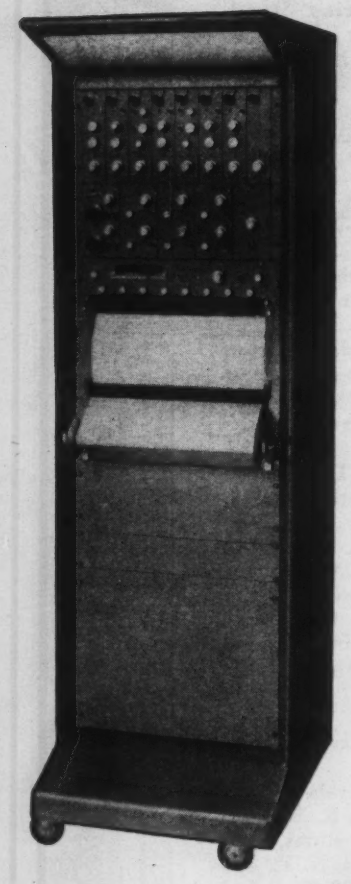
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 10 ON READER-SERVICE CARD

see it at
ISA SHOW
Booth 523

TYPE

THE OFFNER R DYNOGRAPH



The most versatile and sensitive direct-writing unit available!

Ink, heat, electric recording media!

Handles all your recording requirements.

SILVER ANNIVERSARY
1936 1961
25 YEARS
OFFNER DIRECT-WRITING OSCILLOGRAPHS

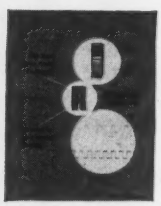
25 years ago Offner invented the world's first Direct-Writing Oscillograph.

This *one* high-speed direct writing assembly handles *all* your recording requirements. You change only the input coupler for thermocouples, strain gages, servo monitors; for industrial, scientific, and medical applications.

☆ From one microvolt, d-c to over 200 cps.

☆ Ink, heat, electric recording media—easily convertible.

Write for complete details.



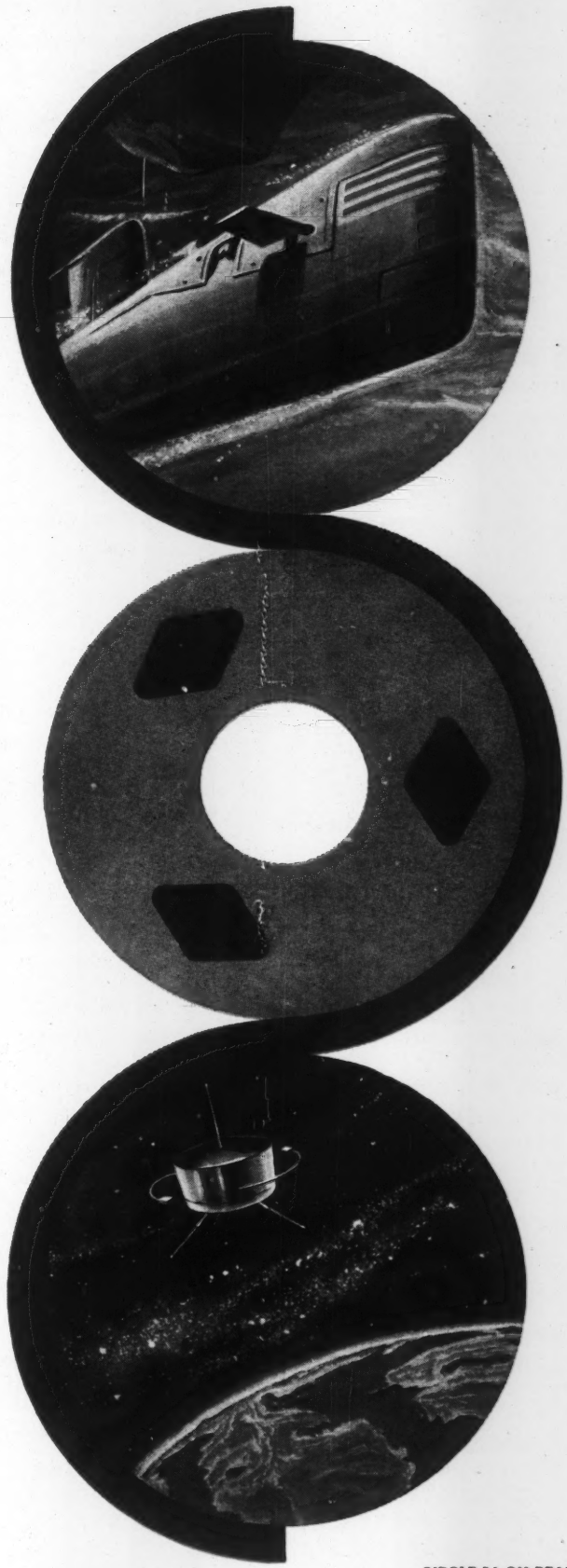
16 pages of facts, figures, and specifications on the Offner Type R Dynograph.

Write for your copy.

OFFNER ELECTRONICS INC.

3910 River Road, Schiller Park, Ill.
(Suburb of Chicago)

CIRCLE 203 ON READER-SERVICE CARD



SOUNDCRAFT INSTRUMENTATION TAPE IN SPACE AND UNDERSEA WITH TIROS II* AND THE SEA DRAGON

The Tape Selected For The Video System In Tiros II! Orbiting with the Tiros Weather Satellite II, developed by RCA for the National Aeronautics and Space Administration, Soundcraft Tape is used exclusively in both narrow and wide angle video tape systems. Only 3/8 of an inch wide, this tape records longitudinally rather than across the width and is the result of over five years of research.

On The Nuclear Submarine, Sea Dragon, the first undersea magnetic video tape recorders also developed by RCA, used Soundcraft instrumentation tapes to record and store data on under-ice characteristics of icebergs and ice flows. As man probes deeper and deeper into the unknown, science continues to call on the world's most modern tape plant for reliable magnetic tapes.

Discover how Soundcraft's consistent record of accomplishment can be extended and applied to fulfill your recording needs. Write for complete literature.

*Soundcraft Instrumentation Tape is, of course, used in Tiros I, and in other vital space projects as well.

REEVES SOUNDCRAFT CORP.

Main Office: Great Pasture Road, Danbury, Connecticut
New York: 10 East 52nd St. ■ Chicago: 28 East Jackson Blvd.
Los Angeles: 342 North LaBrea ■ Toronto: 700 Weston Road

R-131

CIRCLE 16 ON READER-SERVICE CARD

TRENDS

Market for electrohydraulic servo valves is estimated at approximately $40 million (110,000 units) in 1960, including military and commercial types. Market has been increasing 15% annually since 1957; will continue at same rate. Major growth area is industrial segment.

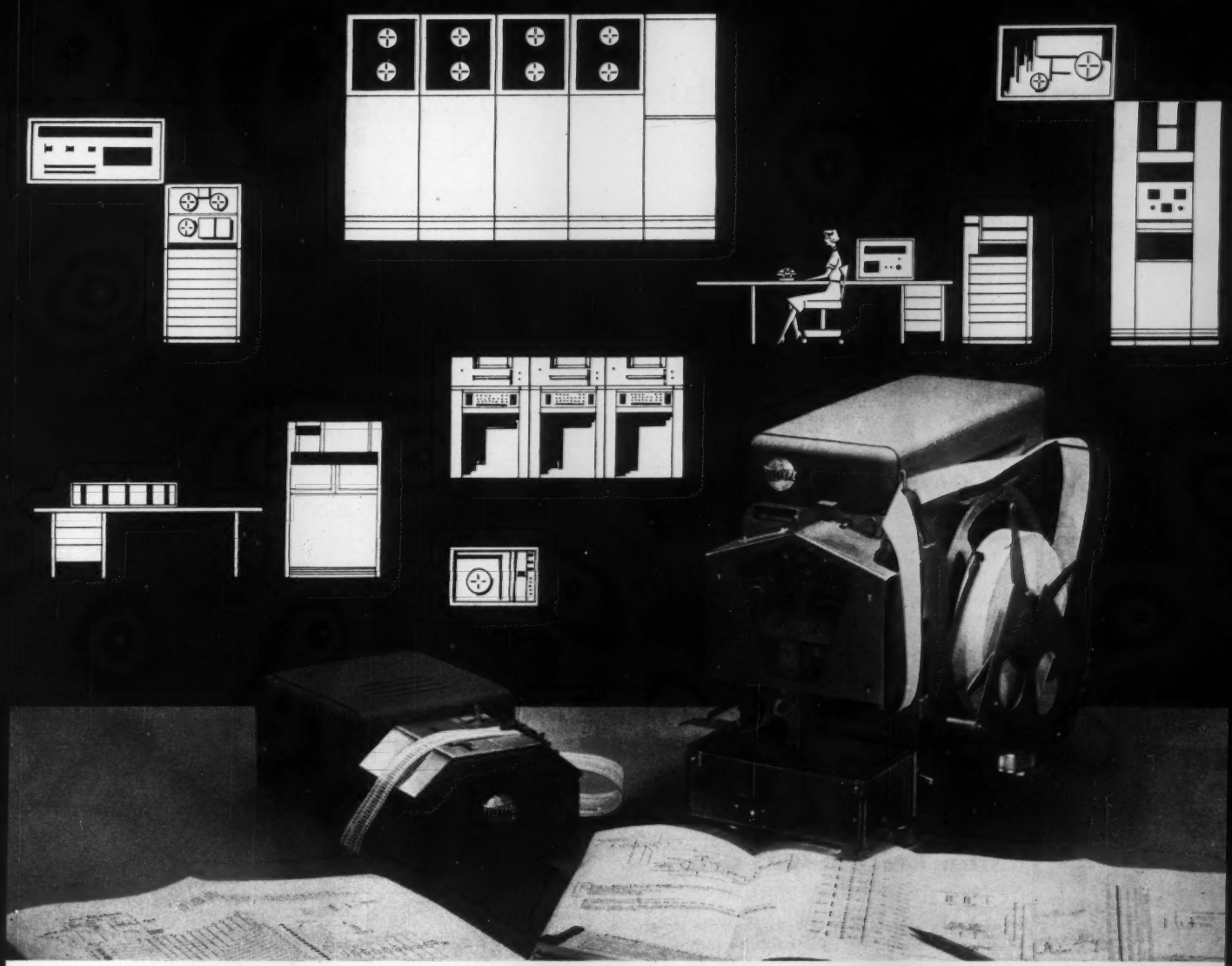
May saw no change in the prevailing downward trend of demand for engineers and scientists says monthly Engineer/Scientist Demand Index (based on recruitment ads, issued by Deutsch & Shea, Inc., New York). May, 93.7, is the lowest recorded in 1961, and might have been somewhat lower but for recruiting activities at a major technical convention on the West Coast. ENGINEER/SCIENTIST DEMAND INDEX (July-Dec., 1960—100.0): March—109.8; April--95.3; May—93.7

Policy document "Investing in Scientific Progress," released by the National Science Foundation, shows that if present trend is maintained we will have twice as many scientists in 1970 as we have now. During fiscal year 1961 the USA invested from all sources a total of $3 billion in colleges and universities for science and engineering education and for basic research, the report notes. This investment must grow to at least $8.2 billion in fiscal year 1970 to achieve the goal. Nation's total annual expenditure for science and engineering education and for basic and applied research is now about $10 billion, only about 2% of the $505 billion Gross National Product. Report states that colleges and universities now have a deficit of about $300 million worth of science teaching equipment, $500 million worth of science laboratory buildings. Report also shows that the percent of the "doctoral age group" earning doctorates in science and engineering has been doubling every 12 years. In 1960, 6,600 such degrees were granted; there will be a potential 13,000 in 1970.

Colleges and universities spent $154 million during 1958 for facilities and other capital items needed for research and development purposes in the natural and social sciences, the National Science Foundation reports. Approximately three-fourths ($112 million) of the total funds expended for R&D facilities came from non-Federal sources—institutions' own funds, State appropriations, or private endowments; the remainder was contributed by the Federal Government. By field of science, expenditures were distributed as follows: life sciences, 50%; physical sciences, 33%; engineering, 15%; social sciences, 3%. The large percentage in the life sciences reflects the need for costly medical-school facilities. (From Reviews of Data on Research & Development, No. 28, "Capital Expenditures for Research and Development in Colleges and Universities, Fiscal Year 1958," released from Superintendent of Documents, U.S. Government Printing Offices, Washington 25, D. C., 5 cents.)

76% of all engineers and scientists employed by the U.S. electronics industry are supported by government funds, reports survey by the Electronic Industries Association with Department of Defense. Remaining 24% is engaged in commercially supported activities. Estimated 155,000 engineers and scientists perform electronics work in all areas. 83% (128,000) are employed by industry; 8% are working for Federal Government; 5% are doing research work for universities and non-profit organizations. Remainder comprises independent consultants, engineers and scientists between jobs, and those not identificable.

CIRCLE 17 ON READER-SERVICE CARD ⟶



New Teletype 1000-speed tape units

Here are two new units that offer the advantages of punched paper tape at 1000 words per minute—and combine traditional Teletype dependability with design simplicity and relatively low cost. Used together, the CX reader (left) and BRPE punch (right) are ideal for tape-to-tape communication of bulk message or statistical traffic via the new Data-Phone service. The reader and punch may also be used individually for communicating data to or from computers, and other devices associated with data processing, telemetering and similar communications functions.

These high-speed units operate on a parallel-wire signal path, in either transistorized or vacuum tube circuits. For serial transmission over conventional voice channels, signals can be converted by external facilities. A pulse generator, adjustable through a full 360 degrees, triggers the external signal storage and provides optimum synchronization of intelligence transfer.

Tape Reader—Will read chadless or fully perforated tape, in 11/16", 7/8" or 1" tape widths. Includes a set of auxiliary timing contacts that operate simultaneously with the sensing pins and assure accurate synchronization with associated transmitting equipment. Dimensions: 5" high, 6" wide, 11" deep. Models available for reading 5, 6, 7, or 8 level codes.

Tape Punch—Produces fully perforated tape. Equipped with "low tape" warning mechanism which can be wired to external alarms. Tape container designed for easy access. Dimensions: 12" high, 8" wide, 16½" deep. Available in two models—one for punching standard 5-level communications code (11/16" tape); the other adjustable for punching 6, 7 or 8 level codes (7/8" or 1" tape).

Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications facilities. For free descriptive literature on the CX and BRPE units, write Teletype Corporation, Dept. 22-H, 5555 Touhy Avenue, Skokie, Illinois.

TELETYPE®
CORPORATION • SUBSIDIARY OF *Western Electric Company* INC.

What's YOUR Portable Power Problem?...

BURGESS has more than 5000 battery types to choose from:

ZINC-CARBON
MERCURY
NICKEL-CADMIUM
WATER-ACTIVATED

each with the highest measure of uniform dependability! This is why 2 of 3 electronic engineers specify

BURGESS BATTERIES

The Most Complete One-Source Line of PORTABLE POWER!

ZINC-CARBON

Most popular source of portable power, zinc-carbon batteries excel in adaptability, availability and economy. Burgess offers the widest range of choice in cylindrical and flat cells, plus exclusive patented "wafer-cell" construction for more compact power and uniform performance.

MERCURY ACTIVATORS

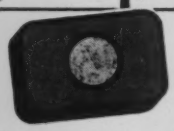
Burgess Quality-Controlled mercury batteries assure uniform operation over wide temperature range, high ampere-hour output, flat discharge curve. Long, non-fading service for instruments, transistor radios, portable electronic products.

SEALED NICKEL-CADMIUM BATTERIES

A secondary rechargeable battery system which delivers high energy output from a small package! Hermetically sealed-in-steel cells eliminate maintenance and addition of liquids. Can be recharged many times, by trickle or quick charge, for long lasting economical power!

RESERVE BATTERIES

High energy output in a compact power source. Can be stored dry for years! Activated only when immersed in water. No handling of dangerous electrolyte, no spilling or leaking! Wide range of efficient operating temperatures. Designed for your specific applications.



EXCLUSIVE WAFER-CELL

This construction offers compactness, long shelf life, exceptional service life. A 30% increase in battery life at no increase in size.

Check with your Burgess Distributor for complete local stocks of fresh BURGESS BATTERIES! Or your distributor can order from Burgess the special battery needed for your specific application!

FREE DESIGN SERVICE

For special applications, skilled Burgess Engineers offer you a FREE battery design service. Burgess will manufacture the exact battery to fit your needs, regardless of quantity required.

NEW ENGINEERING MANUAL

New 100-page dry battery handbook now available! Engineers engaged in the design of battery-powered equipment are invited to write to Burgess Battery Company, Dept. ED, Freeport, Ill., to secure a copy. Others may buy the manual for $1.00.

BURGESS BATTERY COMPANY
Division of Servel, Inc.
FREEPORT, ILLINOIS

CIRCLE 18 ON READER-SERVICE CARD

IGS STOCK REPORT

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

Bache & Co. — NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1961 THRU JULY 25, 1961

	High	Low	Price as of 7/25/61
ACF Industries	60	38	57 3/4
Aeroquip Corp.	36 5/8	22 1/4	29 3/8
Allis Chalmers	29 1/2	23 3/8	25 3/8
American Chain & Cable	53	42 7/8	45 3/4
Amer. Mach. & Foundry	63 5/8	42 1/8	42 1/8
Amer. Mach. & Metals	48	34 1/8	42
American Meter	53 3/4	43	47 3/4
American Optical	78 3/8	54	69 1/8
American Tel. & Tel.	130	103 1/8	120 1/8
Ampex Corp.	27 3/4	18 1/2	19
Aro Equipment	35 1/2	20 1/8	34
Bausch & Lomb Optical	48 1/2	38 1/4	44 1/4
Beckman Instruments	145 3/4	87	124 3/4
Bell & Howell	69 7/8	48 3/4	56 1/2
Bendix Aviation	72	58	64 7/8
Boeing Airplane	51 7/8	35 1/2	51 7/8
Bullard	19 3/8	11 1/4	14 3/8
Bulova Watch	22 1/4	15 7/8	17 1/4
Burroughs	38 1/4	27 1/2	31 3/4
Carborundum	60 1/4	44 1/4	56
Cinn. Milling Machine	49 1/4	37 1/2	40 1/2
Clevite	71 1/4	47 3/4	59
Columbia Broadcasting Sys.	42 3/8	34 3/4	35 3/4
Consol. Electronics	46 1/2	36 1/8	39 3/4
Corning Glass	194 3/4	167	169
Curtiss Wright	22	15 5/8	18 3/4
Cutler-Hammer	82	62 3/8	77
Daystrom	34 3/4	25 1/8	26 1/4
Douglas Aircraft	38 1/2	28	34 1/4
Eastman Kodak	119 3/4	102	102
Eaton Mfg.	38	30 3/8	35 3/8
Electric Auto-Lite	67 3/4	44 5/8	63
Elgin Watch	16 7/8	11 3/4	12 3/8
Emerson Electric	87 1/2	50	74
Engelhard Industries	33 7/8	18 1/2	24 1/4
Food Mach. & Chem.	76 1/2	59 1/8	67 7/8
Foxboro Co.	87	66 3/4	67 1/2
Garrett	56 3/8	44 3/8	46 1/4
General Controls	22 1/2	16 1/2	16 1/4
General Dynamics	45 1/2	31 1/2	35 7/8
General Electric	74	60 1/2	62 7/8
General Instruments	55 1/2	37 5/8	40 3/8
General Mills	37	31	33
Gen. Precision Equip.	78	54 1/2	70 5/8
Gen. Railway Signal	54 3/4	29	43 5/8
Gen. Tel. & Elect.	32 1/2	25	25 1/2
General Time	20 3/8	13 1/2	13 5/8
General Tire & Rubber	79 3/8	53 3/4	73 7/8
Hewlett-Packard	53	34 5/8	37
International Bus. Mach.	499	447	465
International Resistance	42 1/8	26	33 1/4
International Tel. & Tel.	60 7/8	44 3/4	54 5/8
I-T-E Circuit Breaker	24 5/8	17 3/4	18
Lear Inc.	29 3/8	16	24 1/2
Litton Industries	143	87 1/3	126 1/2
Lockheed Aircraft	48 5/8	26 1/2	48 5/8
Magnovox	96 3/4	46	86
Mallory	60 3/8	36 5/8	53 3/8
Manning, Maxwell & Moore	30 3/8	21 7/8	27
Minneapolis-Honeywell	170 3/4	136 1/4	146
Minnesota Mining & Mfg.	87 5/8	70 1/8	78 1/2
Motorola	100	75 1/8	88
National Acme	59 1/2	47	52 1/2
National Cash Register	104 1/2	61 7/8	98
Neptune Meter	29 1/2	22 7/8	27 1/4
North American Aviation	53 5/8	41 5/8	50 3/4
Northrop Aircraft	67 3/8	41 1/2	61
Otis Elevator	80 1/2	56 1/2	80 1/4
Philco Corp.	25 5/8	17 3/4	21 3/8
Radio Corp. of Amer.	65 5/8	49 1/2	57 1/4
Raytheon Mfg.	43 1/2	35 1/4	38 3/8
Reliance Electric	67	47 1/2	49-49 3/4 (a)
Rheem Mfg.	23 1/2	13 1/2	16 7/8
Robertshaw Fulton	47 3/4	32 7/8	44 1/2
Royal McBee	19 3/8	13 1/8	13 1/2
Sangamo Electric	22	14 3/8	18
Siegler Corp.	34	26 1/8	28 7/8
Sperry Rand	35	20 1/2	28 1/8
Square D	43 5/8	29 5/8	39 1/4
Standard Kollsman	53 1/4	25 1/8	46 7/8
Starrett (L.S.)	22	17 3/4	20
Stewart-Warner	32 1/4	24 3/4	30 5/8
Telautograph	20 7/8	12 5/8	14 7/8
Texas Instruments	206 3/4	137 1/2	150 1/4
Thompson-Ramo-Wooldridge	82 3/8	55	58 1/2
Tung-Sol Electric	33 3/8	25 3/8	27 1/2
Underwood Corp.	65 1/2	42 1/2	47 1/8
Union Carbide Corp.	144	116	134
United Shoe Machinery	76 1/4	54 5/8	68
Varian Associates	77 3/8	46 5/8	54 1/4
Wallace & Tiernan	41 1/2	26 1/2	38 3/8
Western Union	55	39 3/4	41 7/8
Westinghouse Air Brake	28 3/4	22	25 1/8
Westinghouse Electric	50	40	41 5/8
Worthington Corp.	67 1/4	49	59

These prices and price ranges are given as printed in the Wall Street Journal.

(a) Not traded, bid and asked.

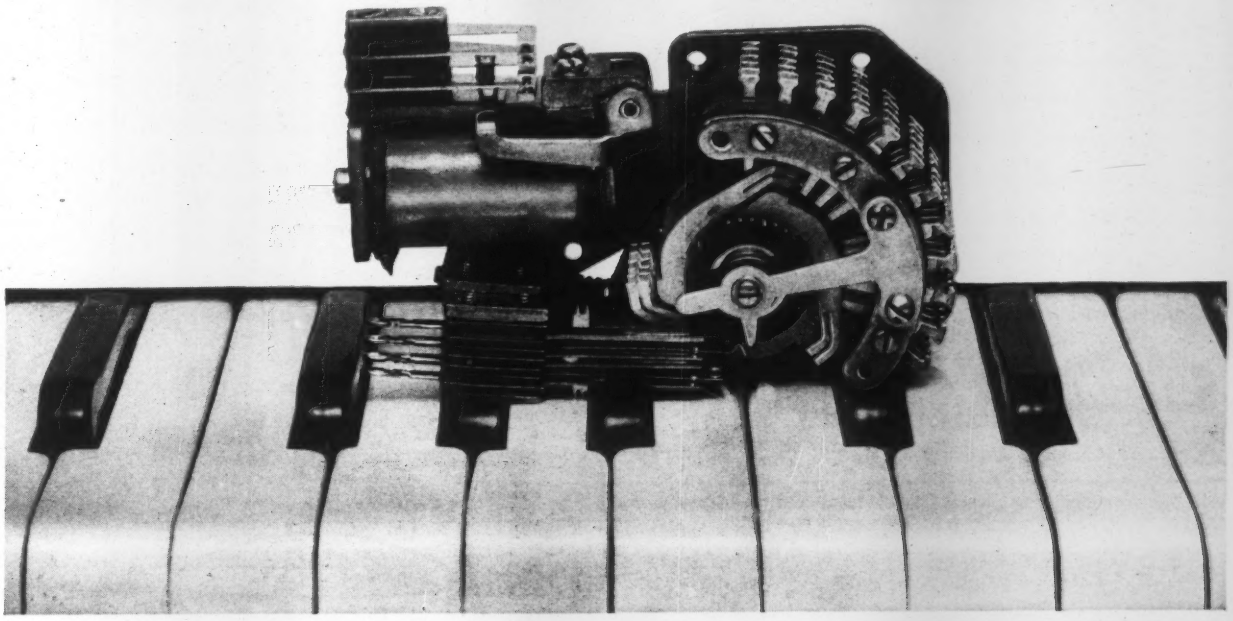
AMERICAN STOCK EXCHANGE

PRICE RANGE 1961 THRU JULY 25, 1961

	High	Low	Price as of 7/25/71
Barry Wright	29 3/4	15	23 1/2
Beloch Instruments	20 1/4	14 1/8	14 1/2
Benrus Watch	11 1/2	6	9
Breeze Corp.	9 5/8	4 1/8	7 1/2
Burnell & Co.	17 3/8	6 1/2	12 5/8

Continued on page 1354

AE



To the Engineer

looking for a small-scale switch to do a large-scale job

If you have to perform complex switching maneuvers, fast, and in small space, you'll go for AE's Type 44 Rotary Stepping Switch.

This mere handful of rugged switching accommodates up to six bank levels, with 10 points plus home—will do the work normally assigned to whole banks of relays.

The miniature Type 44, and its big brother, Type 45, are the only stepping switches with a positive-action, free-floating pawl. This unique design eliminates armature-stop and pawl-stop readjustment — prevents pawl wear-and-tear, breakage, and binding. The pawl locking teeth position the rotor automatically, making overthrow impossible.

Incidentally, AE engineers are artists at composing simple circuits to do complex things – and AE can supply assembled and prewired control packages to your specs. Either way, we can help you cut costs.

For answers to *your* automatic control problems, write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1698-H on Rotary Stepping Switches.

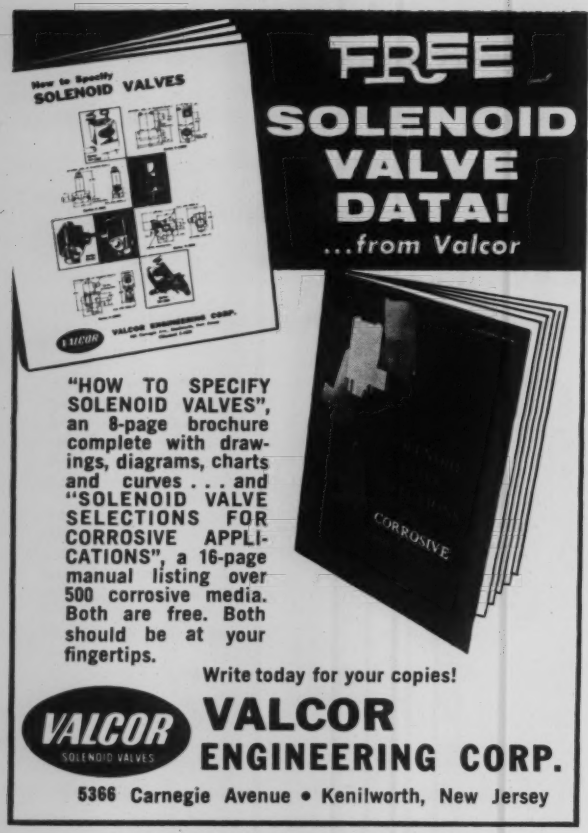
AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

CIRCLE 19 ON READER-SERVICE CARD



"HOW TO SPECIFY SOLENOID VALVES", an 8-page brochure complete with drawings, diagrams, charts and curves . . . and "SOLENOID VALVE SELECTIONS FOR CORROSIVE APPLICATIONS", a 16-page manual listing over 500 corrosive media. Both are free. Both should be at your fingertips.

Write today for your copies!

VALCOR SOLENOID VALVES

VALCOR ENGINEERING CORP.

5366 Carnegie Avenue • Kenilworth, New Jersey

CIRCLE 20 ON READER-SERVICE CARD

Clark Controller	21 1/4	16 1/2	17 5/8
Clarostat Mfg.	20	12	13 1/2
Clary Corp.	22 3/8	8 5/8	13 1/4
Cubic Corp. (New, 3 for 1 split)	32 1/2	24	31
Dynamics Corp. of Amer.	20 1/4	7 5/8	15 1/8
El-Tronics	9 3/4	5	5 5/8
Electronics Corp. of Amer.	14 1/2	9	10 7/8
Fairchild Camera & Instruments	195 1/2	130	153 1/2
Fischer & Porter Co.	31 7/8	16	25 5/8
Giannini Controls	82 1/4	52	63
Globe Union	35 1/2	23 1/2	33 3/8
Hazeltine Corp.	47 7/8	25 1/2	39
Loral-Electronics	46 1/4	31 5/8	38 1/8
National Research	31 7/8	17 5/8	24 1/4
New Haven Clock	2 1/2	1 1/8	1 7/8
Nuclear Corp. of Amer.	8 1/4	3 7/8	5 5/8
Philips Electronics, Inc.	39 1/2	31 1/4	35¼-36¼ (a)
Pneumatic Scale	50	39	42 1/2
Polarad Electronics	28 3/8	18 3/4	20
Servo Corp. of Amer.	19	11	11 1/4
Servomechanisms	13 1/4	7 3/4	11 1/4
Statham Instruments Inc.	35 3/8	22 1/8	22 3/4
Textron Electronics	14 3/8	8 3/8	8 3/4
Victoreen Instrument Co.	19 1/4	13 1/8	14
Waltham Prec. Instr. Co.	4 7/8	1 3/4	2 7/8

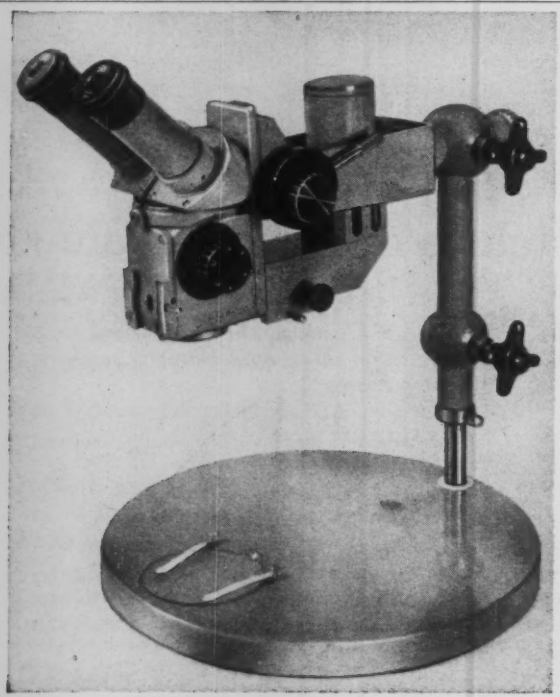
These prices and price ranges are given as printed in the Wall Street Journal.

(a) Not traded, bid and asked.

OVER THE COUNTER

Quotation As of July 25, 1961.

	Bid	Asked
Aerovox Corp.	11 1/4	12 5/8
Argus Corp.	39 1/2	40 1/4
Black Sivalls & Bryson Inc.	12 5/8	13 3/4
Computer Systems	22	24 1/2
Eitel McCullough	15 3/4	15 7/8
Electro Instruments	17 1/2	20
Electronics Associates	29 1/4	30 1/2
Erie Resistor Corporation	13 3/8	14 1/4
Fisher Governor Co.	25 1/4	26
Hagan Chemicals & Controls	53	55 1/2
Milgo Electronic Corp.	18 1/2	20 1/2
Industro Transistor	2 1/2	3 3/4
Liquidometer Corp.	14 1/2	16
Maxson Electronics	20	21 1/2
Penn Controls	22 1/2	23 1/2
Speer Carbon, Inc.	31 1/4	32 1/2
Sprague Electric	79	81 1/2
Taylor Instruments	46 1/2	48 1/2
Telechrome Mfg. Corp.	9 1/4	10 1/4
Telecomputing Corp.	6 1/4	7 7/8
Vitro Corp. of Amer.	24	25 1/4
Wallson Associates Inc.	3 1/2	4 1/2



CARL ZEISS

EPI-TECHNOSCOPE

MADE IN WEST GERMANY

A modern stereoscopic binocular microscope eminently suited for industrial inspections and examinations.

Intense illumination parallel with line of vision. Erect, plastic image even in deep cavities.

Free working distance of 8 inches. Magnification changing device provides rapid succession of 6.3x, 10x, 16x, 25x and 40x magnifications.

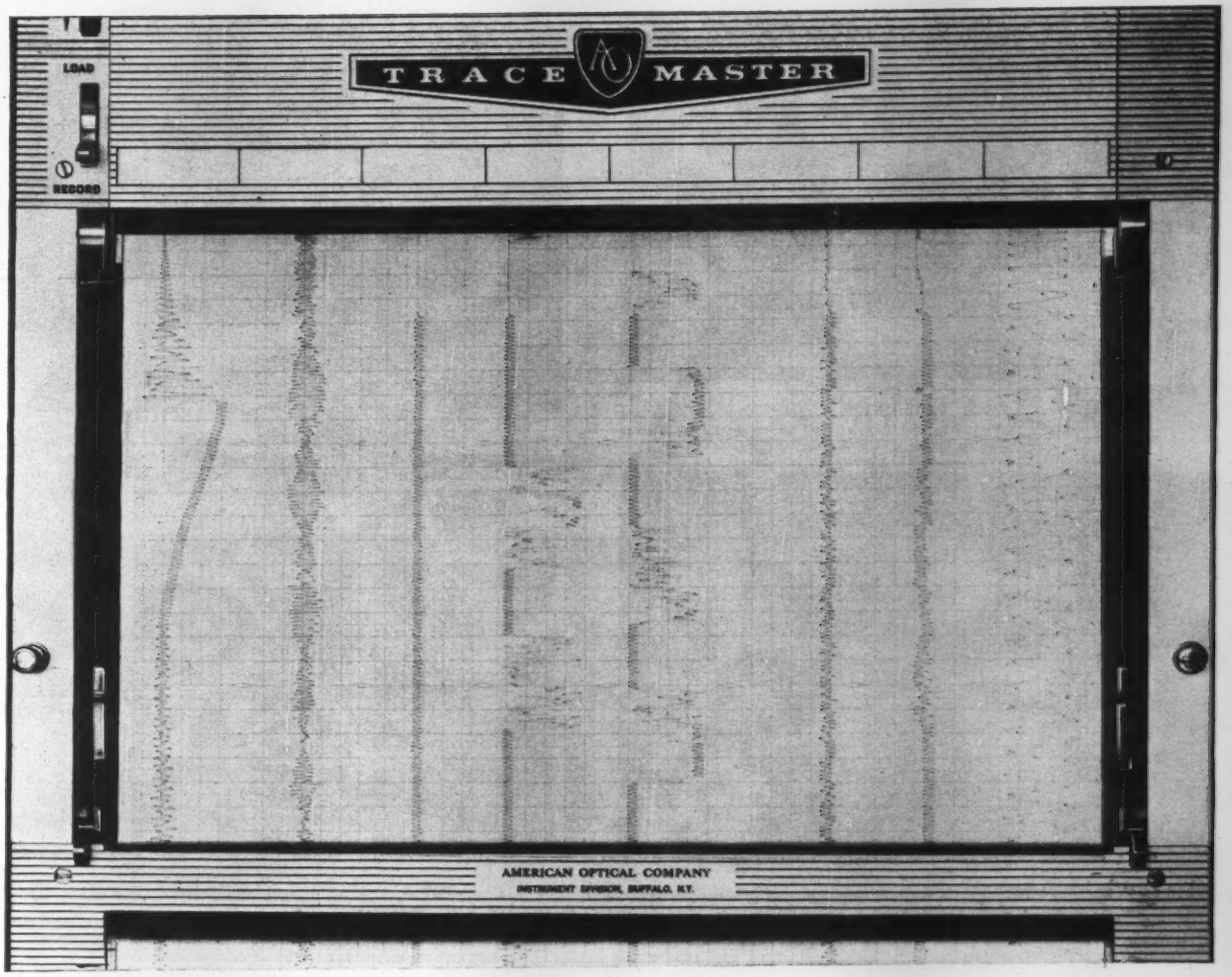
Write for free detailed literature.

CARL ZEISS, INC.

COMPLETE SERVICE FACILITIES

485 FIFTH AVENUE, NEW YORK 17, N. Y.

CIRCLE 21 ON READER-SERVICE CARD



AO Trace-master provides twice the definition of any other direct writing technique

The unique direct-carbon-transfer writing method produces a trace from 2 to 3 times finer than any other direct-writing technique. This allows twice as many lines per millimeter . . . **twice the definition!** Resolution is unsurpassed . . . each line is uniform in width and contrast, revealing the most minute variations in the phenomena measured with utmost fidelity. This writing technique combined with the advanced pen-motor design produces a wider frequency response **at larger amplitudes.** Continuous recording of data can be displayed simultaneously on 8 channels . . . up to 8 independent event markers can be added. Ten chart speeds — 0.1 to 500 mm/sec — provide a 5000:1 chart speed ratio.

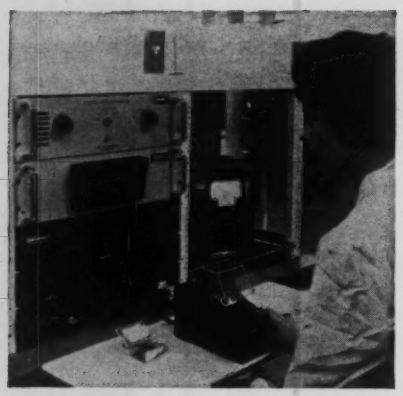
The AO Tracemaster has become the new standard of performance for these and many other reasons . . . write now for the full story!

See the AO TRACE MASTER . . . plus other advanced direct writing recorder instrumentation at I.S.A. Booth 323

American Optical COMPANY

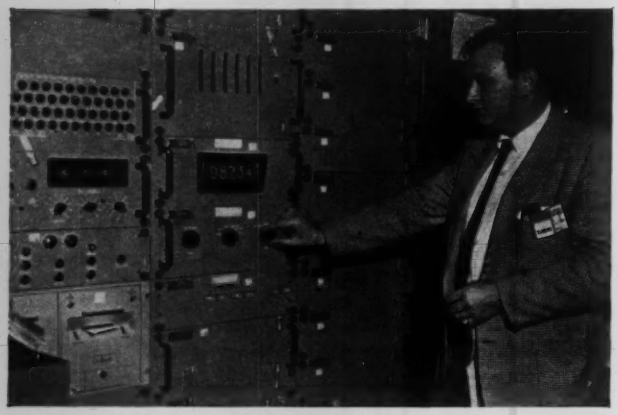
INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

CIRCLE 22 ON READER-SERVICE CARD

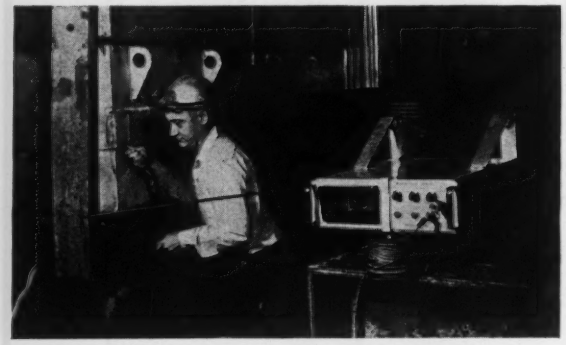


FINAL PRODUCTION TESTING. Zener diodes are checked by NLS M24s at final testing stations of Hughes Aircraft Company's Semiconductor Division.

CHECKOUT OF MISSILE COMPONENTS. An M24 checks electronic components at Autonetics, a division of North American Aviation, Inc., as part of the High Reliability Program for Minuteman ICBM. The operator is shown measuring resistance. By turning a front panel knob on the M24, she can also measure DC voltage or DC voltage ratio.



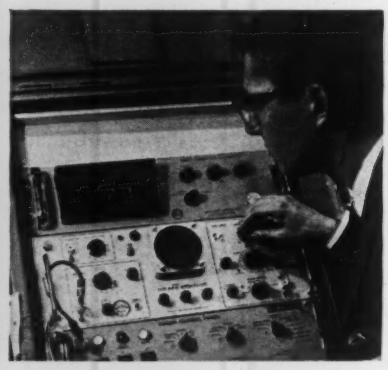
MISSILE PRODUCTION TESTING. An NLS M24 Multi-Purpose Instrument performs an important part in the missile functional test system at Boeing Airplane Company's Missile Production Center in Seattle, Wash. The system automatically applies more than 400 go/no-go sequenced tests to ground-check missile flight reactions from launch to intercept. The M24 and the printout portion of the system monitor application of test stimuli and isolate malfunctions.



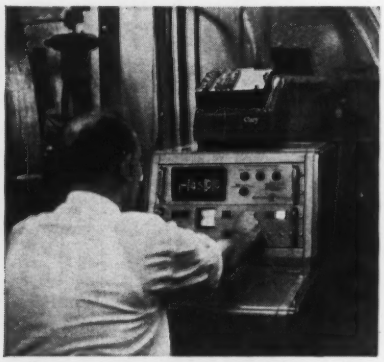
ELECTRO-CHEMICAL ANALYSIS. Savings of as much as $8,000 a year on one particular project are expected to result from use of an NLS 481 DVM at Diamond Alkali Company's plant in Deer Park, Texas. By accurately measuring small changes in voltage and voltage drop, it permits optimizing the efficiency of producing chlorine from sodium chloride brines by electrolysis.

ACCEPTANCE...

PETROLEUM RESEARCH AND DEVELOPMENT. This precision data logging system, incorporating an NLS V24 DVM, has served Esso Research Laboratories for more than two years in around-the-clock service. The V24 converts millivolt signals to digital form for operating a Friden Tape Punch. The system aids in making pilot plant studies of industrial processes.



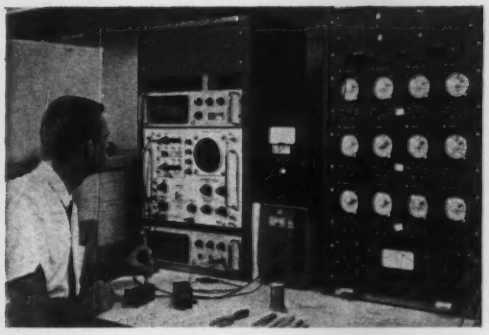
MISSILE TRACKING SYSTEMS. The Azusa Test Set, designed by General Dynamics/Astronautics, A Division of General Dynamics Corporation, includes an NLS V35 DVM. This set checks the power and transmitter portions of the airborne package of the system which is used for tracking all missiles launched from Cape Canaveral. Functions of the V35 include monitoring of 28-, 100- and 1,500-volt power supplies; calibrating telemeter transducers; and adjusting Klystron beam, bias and modulator voltages.



SPACE MEDICINE RESEARCH. In simulated space environment testing, this NLS V34 digital voltmeter is part of a system which detects and records minute changes in body weight, a key factor in determining physiological strain. The unique "No Needless Nines" logic of the V34 permits measurements at pre-selected time intervals with an accuracy of ± 3 grams within a range of $\pm 4{,}500$ grams. AMF's Mechanics Research Division developed the overall system under direction of the Air Force's Aeronautic Systems Division at Wright-Patterson AFB in Ohio.

CIRCLE 23 ON READER-SERVICE CARD

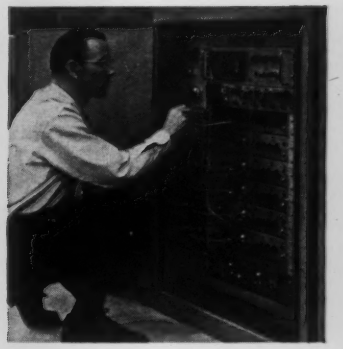
PRODUCTION TESTING. A 481—one of a battery of NLS DVMs—measures Zener diodes for separation into voltage categories at the Semiconductor Products Division of Motorola, Inc. Measuring speed for this operation was doubled by use of the NLS digital voltmeters.



MISSILE CHECKOUT. Two NLS DVMs team up on checkout of equipment for the GAM-77 Hound Dog Missile at the West Coast Laboratories of Mallory Electronics Company, A Division of P. R. Mallory & Co. Inc. The 481 (bottom) calibrates remotely settable timers for the Hound Dog and the V35 (top) is used for final checkout of these devices. "By using DVMs, we are able to eliminate human error in final inspection," said a Mallory executive.

QUALITY CONTROL OF ELECTRONIC COMPONENTS. More than 50 NLS 481 digital voltmeters are used in the Quality Assurance Program at the Semiconductor-Components Division of Texas Instruments Incorporated. The instrument pictured is measuring breakdown voltages of high-reliability germanium switching devices.

MATERIALS EVALUATION. Electronic Chemicals Division of Merck & Co., Inc., uses a 481 DVM to reduce testing time for determining resistivity of single crystal silicon.



A-TO-D CONVERSION IN INDUSTRIAL PROCESSING. A 481 DVM operates an analog-to-digital converter in a variance computer for Saran Wrap production at The Dow Chemical Company's Saran Wrap plant in Midland, Mich.

sign of superiority in digital voltmeters

If you measure or record voltage, consider the broadening applications of digital voltmeters as indicated by these examples. The NLS instruments shown here... and the thousands of others in action today... tell a story of acceptance that is three-fold:

1. The digital voltmeter—first unique instrument since the development of the oscilloscope and vacuum tube voltmeter—has become a *basic measuring and logging tool* since its origination by Non-Linear Systems, Inc., nine years ago.

2. NLS digital voltmeters have been *proved in use* by many of the most discriminating companies in the electronics and allied industries.

3. Most of these firms have *specified NLS again and again,* some owning more than fifty instruments... evidence of the acceptance of NLS, as well as the usefulness of the product it manufactures.

Our point: it makes sense to contact the most experienced manufacturer of digital voltmeters to meet your measuring and data logging needs. Select from the world's most complete line... by purpose... by price. NLS offers 16 basic models—all with exclusive features—from a low-cost "Industrial" type instrument to a $6,150 all-electronic DVM that makes 200 readings per second. For the most complete and authoritative information available on DVMs, contact your local NLS office or rep, or write NLS.

Visit Us At WESCON (Booths 1518-1520) And At The Los Angeles ISA SHOW (Booth 105)

non-linear systems, inc. *Originator of the Digital Voltmeter*
DEL MAR, CALIFORNIA

View the latest in G-E Process-Instrumentation at the National Chemical Show, International Amphitheater, Chicago, Booth 224, Sept. 5-8 and . . .
ISA Conference & Exhibit, Los Angeles Memorial Sports Arena, Booth 702, Sept. 11-15.

PROBLEM: how to collect, record and transmit critical fluid flow data more *accurately* than ever before.

SOLUTION: custom-designed flow measurement systems from General Electric.

RESULT: reliable process control, simplified fluid accounting, precision batch blending and loading.

System instrumentation includes: true mass flowmeter, available in 13 standard ranges ■ null balance recorders, a full line of strip and round-chart ■ new telemetering equipment, analog and digital.
In addition, ticket printers and totalizing counters are available for visual digital display and pre-set counters may be added to provide precision control in blending and loading operations.

FOR FLUID FLOW PROCESS:

In a variety of system applications, these General Electric instruments cut operating costs and boost plant production . . . through *simplified* and *more accurate* measurement. No wonder they've been specified by process engineers throughout the world. *Performance-proved . . . on the line!*
For complete information, contact your nearby General Electric sales office or write Section 599-08, General Electric Co., Schenectady 5, N. Y. for the following bulletins: GEA-6925, Mass Flowmeter; GEA-6887, Null Balance Recorders; GEA-7163, Telemetering Systems. In Canada, contact Canadian G.E. Co. Ltd., 940 Lansdowne Ave., Toronto 4, Ontario. Outside the U.S. and Canada, contact International G.E. Co., 150 E. 42nd St., New York 14, N. Y.

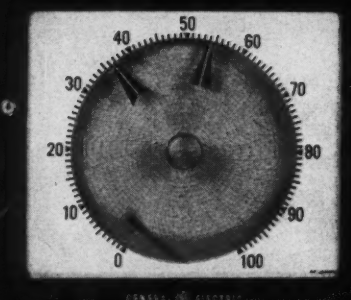
INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

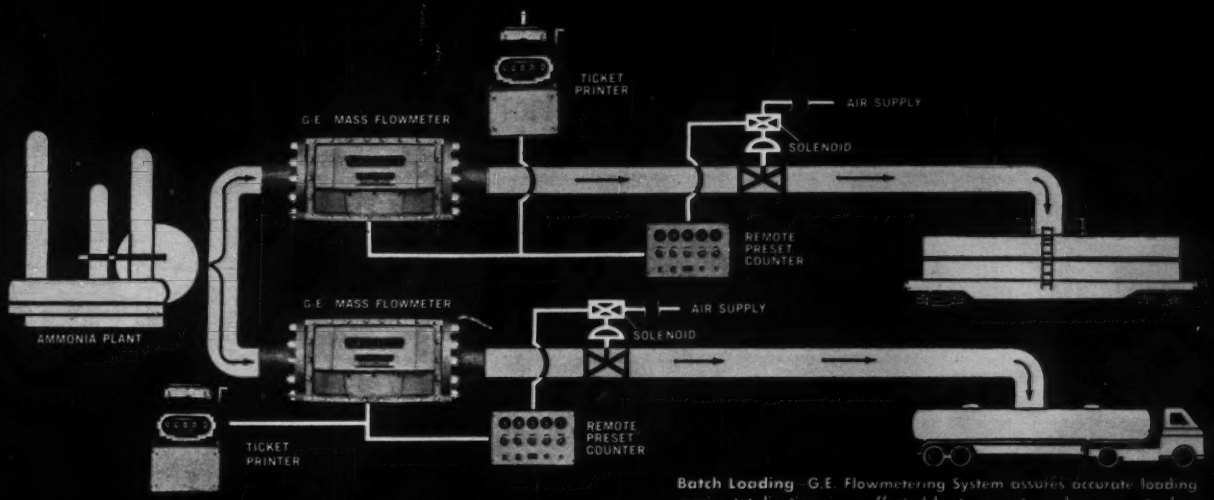
CIRCLE 24 ON READER-SERVICE CARD

Mass Flowmeter measures fluid flow directly in pounds, eliminates volume-to-mass conversion. ±1% accuracy unaffected by change in pressure, density, temperature, viscosity, flow rate. 13 standard ranges now available.

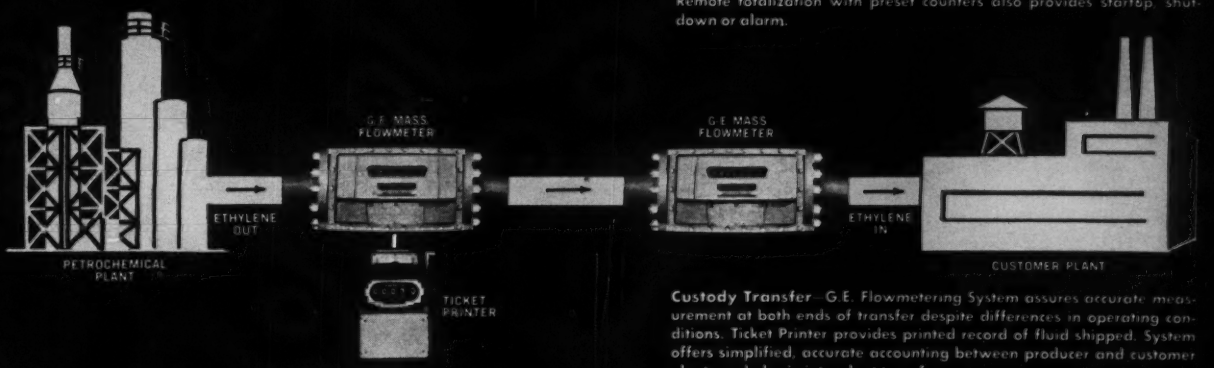
HIGH ACCURACY



General Electric Null Balance Recorders feature: silicon diode reference voltage source for operational reliability; varied control forms for versatile applications; components mounted on swing-out panel to simplify routine maintenance. Full line includes multipoint, single and two-pen—strip or round-chart models.

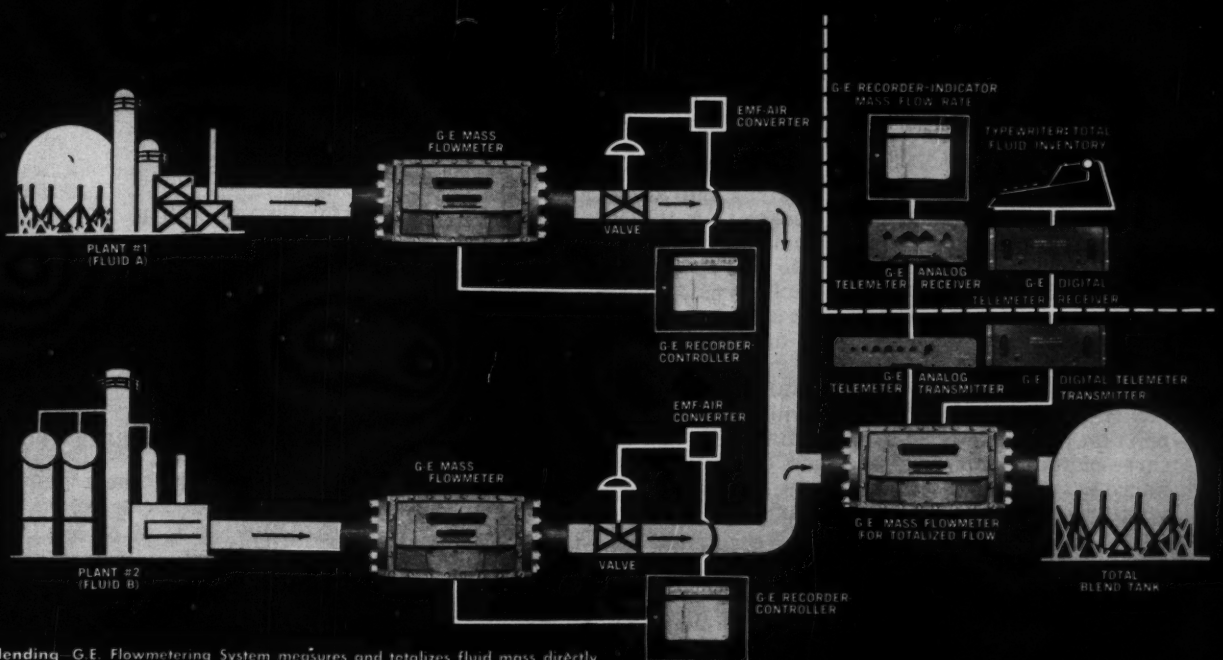


Batch Loading—G.E. Flowmetering System assures accurate loading, precise totalization; is unaffected by temperature changes in tank or pipe. Meter measures different fluids with no calibration change. Remote totalization with preset counters also provides startup, shutdown or alarm.

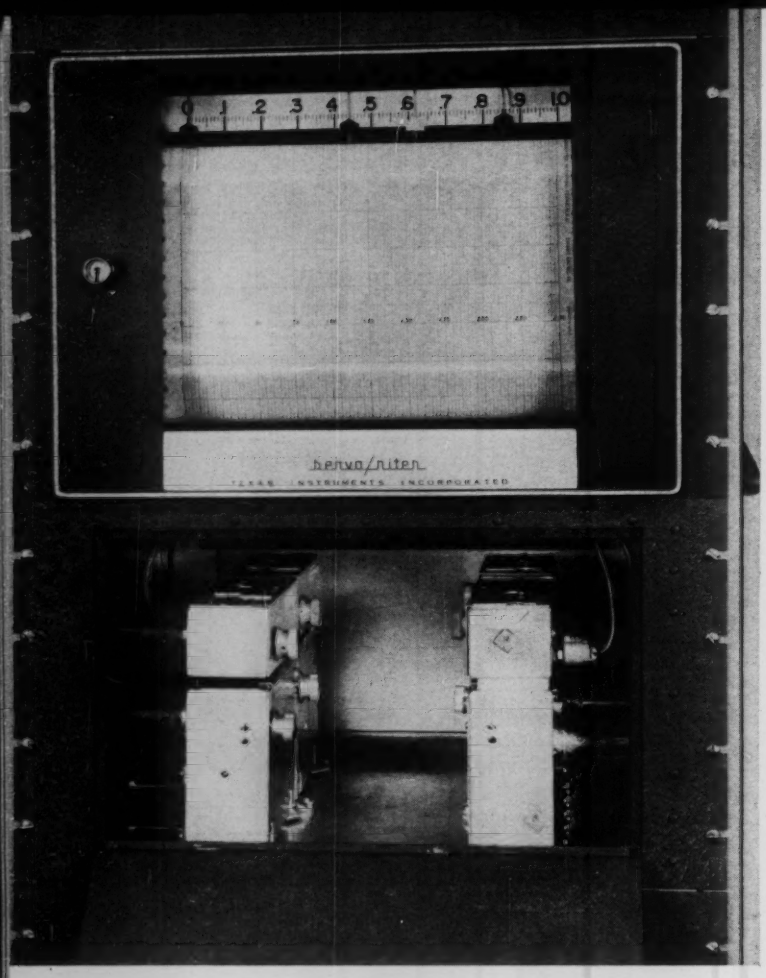


Custody Transfer—G.E. Flowmetering System assures accurate measurement at both ends of transfer despite differences in operating conditions. Ticket Printer provides printed record of fluid shipped. System offers simplified, accurate accounting between producer and customer plants and also in interplant transfers.

MEASUREMENT SYSTEMS FROM GENERAL ELECTRIC



Fluid Blending—G.E. Flowmetering System measures and totalizes fluid mass directly, eliminates laborious volume-to-mass conversions. Predetermining counters assure simplicity and accuracy in blending operations. Data is instantly telemetered to central locations by new G-E Telemetering. Typical blends are refrigerants, solvents and special naphthas.



NEW from TI

4-CHANNEL servo/riter* RECORDER

RECORDS 4 CONTINUOUS CHANNELS ON A WIDE SINGLE CHART

You can now record four continuous channels of data on a wide single chart . . . four overlapping pens continuously recording on the full width of the 9¾" chart. For the first time in a potentiometric recorder four variables can be traced with high resolution on a single sheet of chart paper! The recorder is the proved *servo/riter* in the flush-mounting configuration for use in standard 19" relay racks.

Amplifiers are separate from the recorder and may be mounted as far as 15 feet from the recorder chassis. An optional factory-assembled package places the four amplifiers in a standard rack-mounting case for location adjacent to the recorder case.

In addition, five- and six-channel *servo/riter* recorders are available, utilizing overlapping pens on dual side-by-side 4½" charts. Two- and three-channel recorders are offered in both the narrow and wide configurations, with all pens writing on only *one* sheet of chart paper.

The same industry-proved performance characteristics and wide ranges of the single and dual-channel *servo/riter* recorders are designed into the new multi-channel instruments. These include:

- HIGH SENSITIVITY—
  1.0 mv to 100 mv full-scale
- HIGH INPUT IMPEDANCE—
  4 megohms off-balance
- FAST RESPONSE—
  .5 second full-scale rise time
- HIGH REJECTION RATIOS—

"Transverse"	1,000/1
"Longitudinal"	330/1
d-c Common Mode	30,000/1
d-c & a-c Guard	30,000,000/1

- HIGH RELIABILITY—Non-lash gearing and conservatively rated electronics.

Write for complete information.

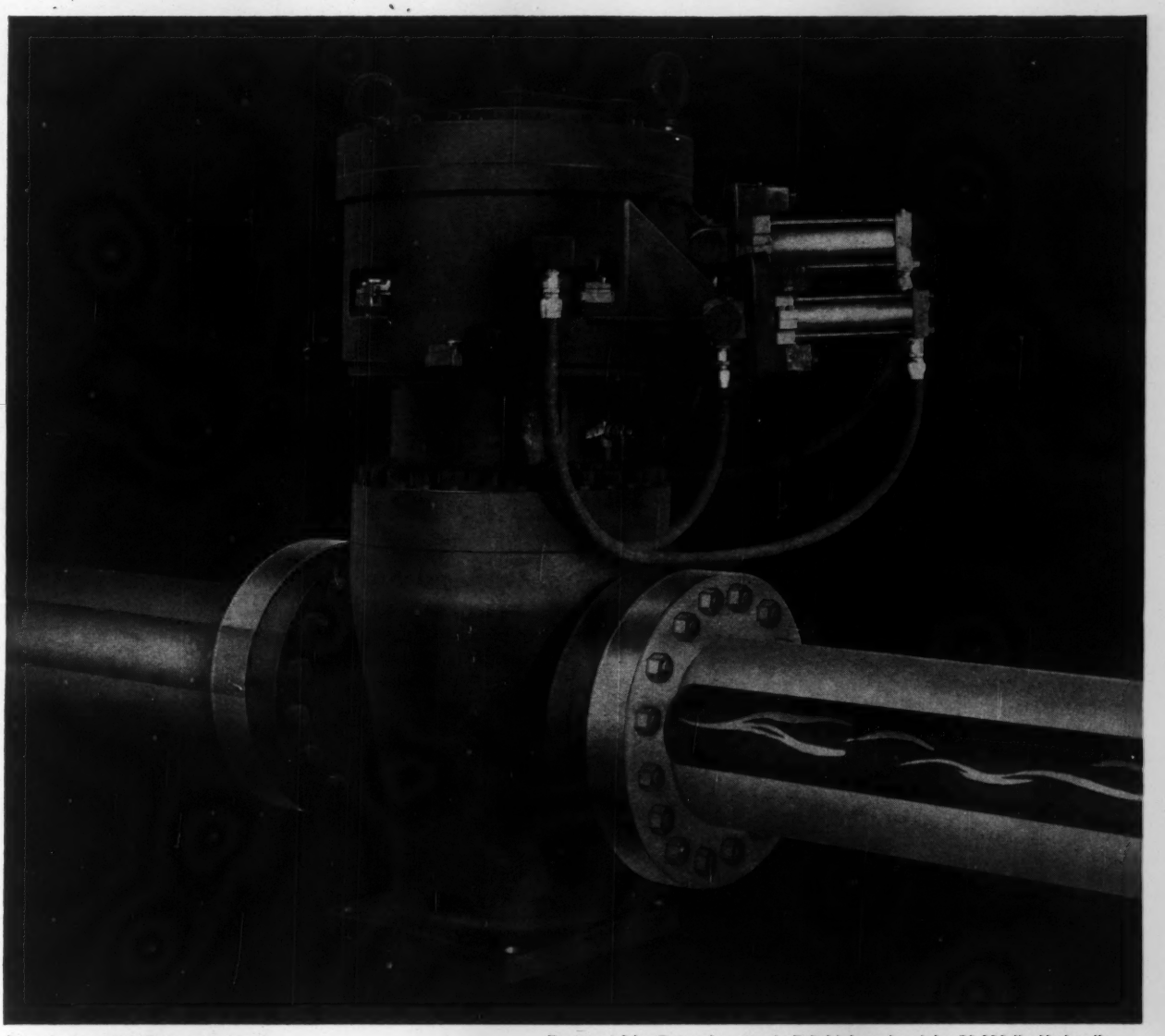
APPARATUS DIVISION
PLANTS IN HOUSTON
AND DALLAS, TEXAS

TEXAS INSTRUMENTS
INCORPORATED
3609 BUFFALO SPEEDWAY
P. O. BOX 6027 HOUSTON 6, TEXAS

CIRCLE 25 ON READER-SERVICE CARD

*Trademark of Texas Instruments

ALLIS-CHALMERS



Rotovalve is an Allis-Chalmers trademark.

Featured 8-in. Rotovalve stands 7 ft high and weighs 50,000 lb. Hydraulic operator works at a pressure of 3000 psi . . . a speed of 1/10th second!

"Putting a stop" to 2500 psi at 2500 F

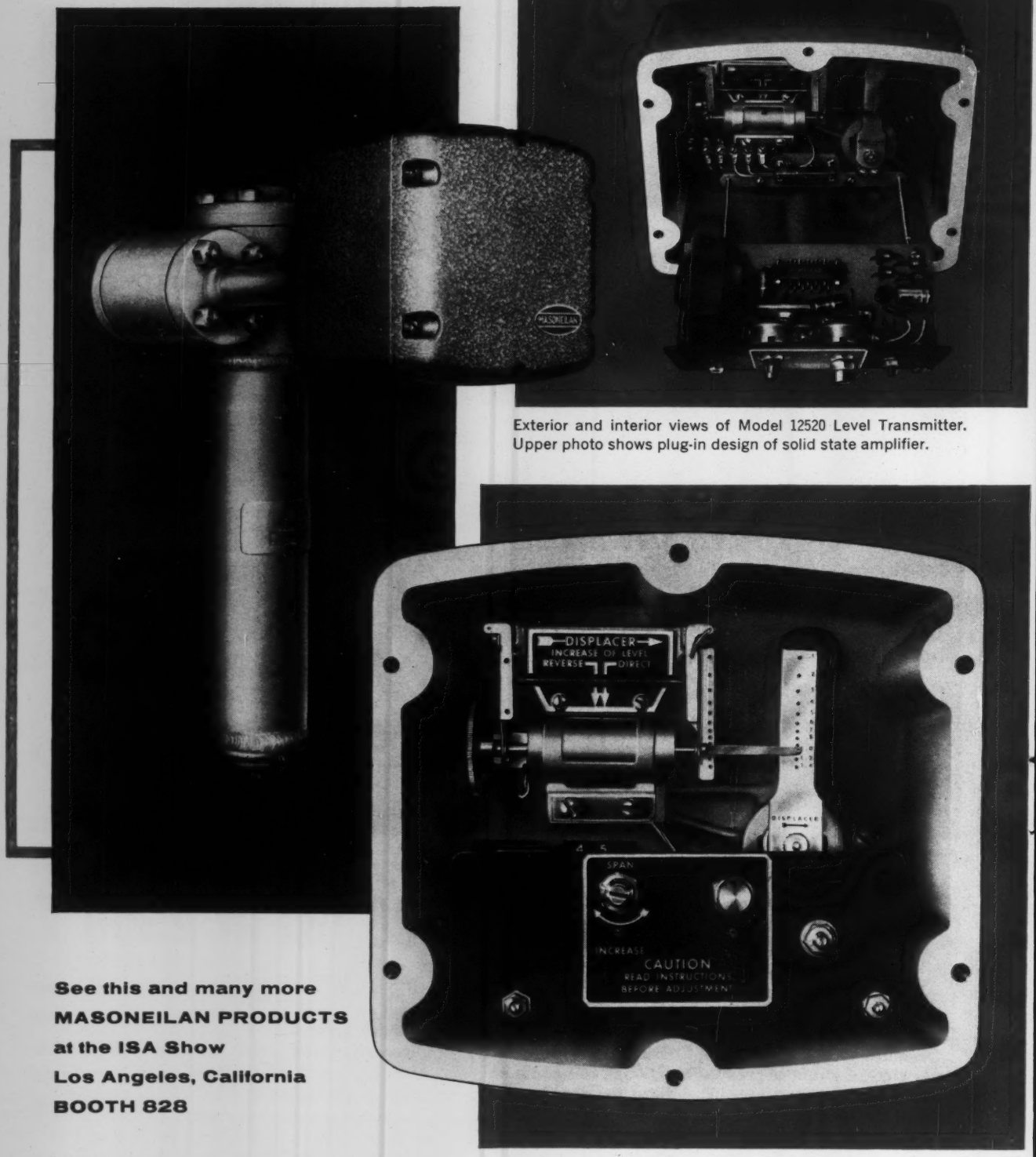
...here's the valve that does it with ease!

This 8-in. *Rotovalve* takes extreme conditions in stride . . . handles 2500 psi at 2500 F. Constructed of chrome-moly steel, it employs internal air cooling to maintain valve temperature at 1000 F despite the *far higher* heat of the liquid or gas being handled.

Allis-Chalmers cone valves *seat even tighter with use* . . . feature lantern ring with double packing, pressurized with the line fluid or purged to a bleed tank at lantern ring. Both standard and special *Rotovalve* units have proved their reliability in thousands of applications, under widely varying conditions.

Any time you face a valving problem, call on your Allis-Chalmers representative. He's equipped to supply "specials" engineered exactly to your application. And he also offers you a complete line of Rotovalve *units and butterfly valves for conventional uses. Contact him for information, or write* **Allis-Chalmers,** *Hydraulic Division, York, Pa.* A-1394

CIRCLE 26 ON READER-SERVICE CARD



Exterior and interior views of Model 12520 Level Transmitter. Upper photo shows plug-in design of solid state amplifier.

See this and many more
MASONEILAN PRODUCTS
at the ISA Show
Los Angeles, California
BOOTH 828

Mason-Neilan Presents.....

A New High-Quality Electronic Liquid Level Transmitter

Making the proven advantages of displacement level measurement available for centralized electronic control systems

Mason-Neilan has utilized the best features of mechanical and electronic design to provide a new device for transmitting dc signals proportional to level variations.

This transmitter combines the time-tested, field-proven variable displacement measuring element made famous by the 12000 Series pneumatic level controllers, with an LVDT displacement transducer and a solid state amplifier. A choice of output signals permits use with any presently available electronic receiver — indicator, recorder or controller.

Consider these important features:

Accuracy . . . within 1%. High feedback serves to maintain accuracy and stability under changing ambient conditions. Torque tube assembly design insures true center of rotation — eliminates objectionable friction.

Reliability . . . solid state circuit with components of the highest quality.

Versatility . . . wide choice of output signals and level ranges. Left or right hand case mounting — reversible in the field. Selection of mounting types to meet all vessel requirements.

Ruggedness . . . sturdy aluminum explosion-proof instrument case provides maximum durability and protection to all internal parts.

Simplicity . . . adjustments are readily accessible and easily made. Plug-in amplifier assembly for convenient maintenance.

Complete data are yours for the asking. If you are now using, or contemplate using, electronic controls, we invite you to get in touch with a Mason-Neilan representative, or write to

MASONEILAN

Products that Work for Your Profit

MASON-NEILAN

Division of Worthington Corporation

55 NAHATAN STREET, NORWOOD, MASSACHUSETTS, U. S. A.

MN 1-20

CIRCLE 27 ON READER-SERVICE CARD

A NEW ADDITION TO THE SONAC *LINE*

POSITIVE ULTRASONIC LEVEL CONTROL

The components of Sonac (sensor actual Size)

Now, two new ultrasonic sensors, especially for level control have been added to the Delavan line of SONAC sensing and switching devices.

The single sensor system is recommended for liquid level control and the double sensor system for dry level control.

Control is maintained by installing the SONAC sensor through the wall of the vat, bin or hopper. When the oscillation on the face of the sensor is dampened or impeded by the material being sensed, the signal to the control unit changes, activating a relay.

FIG. 1—LIQUID LEVEL (One Sensor)

FIG. 2—DRY LEVEL (Two Sensors)

For level control, SONAC is accurate to .005″ and has a response time of 25 milliseconds. Performance of the sensor does not deteriorate with age.

The level control uses to which SONAC can be applied are virtually unlimited. It is not affected by the viscosity*, specific gravity, conductivity, or capacitance of the material being sensed. Temperature or pressure changes of the material do not alter its performance. False signals are eliminated because SONAC may be adjusted so as not to sense steam, foam, or vapors.

*Viscosity may affect response time.

Canadian Representative:

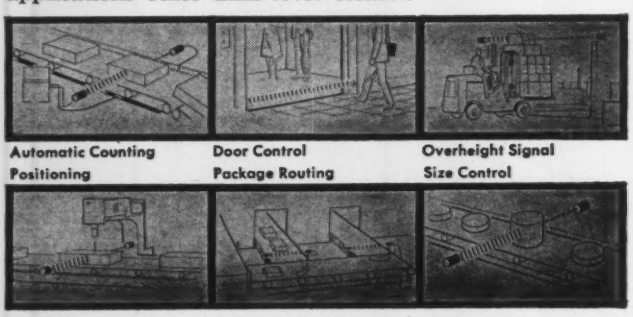
KNOWLES & FOSTER (North America) Ltd.

708 Terminal Bldg., Toronto 1, Ontario, Canada

SONAC is extremely rugged. Sensors are type 304 stainless steel. The electronic components in the sensors are hermetically sealed and will withstand pressures to 2000 psi and temperatures from −425° F. to +450° F. They are immune to shock, vibration or mechanical damage.

The control is a compact unit 5″ x 5″ x 5″ and features transistor circuitry. Power consumption is one watt and the unit will operate in temperature ranges from 40° F. to 135° F.

Here's how SONAC can be used for sensing and switching applications other than level control.



Automatic Counting Positioning | Door Control Package Routing | Overheight Signal Size Control

There are dozens of applications for SONAC *single and double sensor units. Let it go to work for you now, write:*

DELAVAN Manufacturing Company

WEST DES MOINES • IOWA

CIRCLE 28 ON READER-SERVICE CARD

ISA NEWS

Los Angeles Sets Stage for 16th Annual ISA Conference

PITTSBURGH, PA.—The Instrument Society of America's 16th Annual Conference & Exhibit will be held on September 11-15, 1961 in Los Angeles, Calif. The conference with the theme "Reliable Information from Undersea to Outerspace" will be centered in the Biltmore Hotel; the exhibit will be located in the Memorial Sports Arena in Exposition Park.

General Conference Chairman is *Bernard L. Dorman,* vice president of Aerojet-General Corporation; Executive Chairman is *J. J. Groenewegen,* Shell Chemical Company; Technical Conference Program Coordinator, is *J. E. Witherspoon,* Rocketdyne/NAA. A total of 80 technical sessions will be held in five days with approximately 300 authors covering the latest progress in the instrumentation technology.

The opening keynote session on Monday, September 11, will feature four nationally-prominent speakers: *Dr. Roger R. Revelle,* Director of Scripps Institution of Oceanography, University of California whose theme is "Reliable Information from Undersea;" *Dr. Frank B. Goddard,* Assistant Director, Jet Propulsion Laboratory, California Institute of Technology who will speak on "Reliable Information from Outer Space;" *Dr. Allen V. Astin,* Director, National Bureau of Standards who has chosen "Reliable Standards;" and *Robert L. Wehrli,* Vice President, Robertshaw-Fulton Controls Company who will elaborate on "Reliable Information in Industry."

The conference program consisting of technical paper presentations, forums, panels, workshops, and clinics and plant tours will highlight the latest concepts and theories, ideas and applications of instrumentation. Outstanding areas of discussion include: Aero-space, (4 sessions); bio-medical (2 sessions); data handling & computation (8 sessions, including 4 workshops and 2 clinics); management (7 sessions); measurement standards instrumentation (6 sessions); shock and vibration (3 sessions); strain gage instrumentation (5 sessions); other conference sessions include electronic instrumentation, nuclear measurements, feedback control system optimization, photographic measurements, and analysis instrumentation; also oceanographic measurements.

Other organizations cooperating with ISA are ACS, IRE, Professional Group on Reliabiilty and Quality Control, SCMA, PMA, American Meteorological Society (AMS), California Natural Gasoline Association (CNGA), Institute of Management Sciences (IMS), and Temperature Measurement Society (TMS).

A survey of new products to be exhibited begins on page 1489.

Aronson To Moderate Session

PITTSBURGH, PA.—Milton Aronson, editorial director of Instruments Publishing Company, has been invited to moderate the session on "Economic Evaluation of Measurement Standards Programs," September 13, at the Fall ISA Conference in Los Angeles.

Besides Milt Aronson who will give an introductory short paper, there will be four speakers at the session: Dr. John A. Harrington, vice president and director of metrology, Metrolonics, Inc., who has chosen "Managements Evaluation of today's Measurements Requirements," as his topic; William Wildhack, special assistant to the director, NBS, who will speak on "Cost and Value of Accuracy;" Ward B. Dennis, vice president and director of corporate development planning, Northrop Corporation, whose theme is "Management Planning for Measurements Standards Program;" and Dr. L. M. K. Boelter, dean of the College of Engineering, UCLA, who will elaborate on "Metrology and Engineering Education."

	Monday	Tuesday	Wednesday	Thursday	Friday
MORNING SESSIONS	10:00 Keynote Session	Photographic Instrumentation I Strain Gage Instrumentation II Bio-medical Instrumentation I Management Session II Computer Clinic I Education Workshop I ACS, Analytical Chemistry II TMS, Session II Measurement Standards Instrumentation II	IMS, Session I Education Forum, Session I PMA, Session I Data Handling Workshop I Data Handling Workshop II Strain Gage Instrumentation II Marine Sciences I CNGA, Session I Analysis Instrumentation II	Shock and Vibration II Marine Sciences II Aero-Space Instrumentation II Measurement Standards Instrumentation V Management Session IV SCMA, Session I Analysis Instrumentation IV Data Handling and Computation I	Shock and Vibration IV Feedback Control Systems I Pulp & Paper I Electronic Instrumentation I Analysis Instrumentation VI Instrument Mfrs. Session II Marine Sciences IV Aero-Space Instrumentation IV Standard Labs, Session I
AFTERNOON SESSIONS	Measurement Standards Instrumentation I Management Session I AMS, Session I ACS, Analytical Chemistry I Cement & Lime Session I Strain Gage Instrumentation I TMS, Session I Measurement and Control Instrumentation I Nuclear Instrumentation I	Computer Clinic II Bio-Medical Instrumentation II TMS, Session III AMS, Session II FIER—Management III Education Workshop II Strain Gage Instrumentation III Analysis Instrumentation I Measurement Standards Instrumentation III Photographic Instrumentation III	IRE,—PGROC Education Forum II Shock and Vibration I IMS, Session II Aero-Space Instrumentation I Analysis Instrumentation III Data Handling Workshop III Data Handling Workshop IV Measurement Standards Instrumentation IV CNGA, Session II	Chemical & Petroleum Instrumentation II SCMA, Session II Measurement Standards Instrumentation VI Data Handling and Computation II Aero-Space Instrumentation III Marine Sciences III Instrument Mfrs. Session I Management Session V Analysis Instrumentation V	Standard Labs, Session II

CIRCLE 29 ON READER-SERVICE CARD ⟶

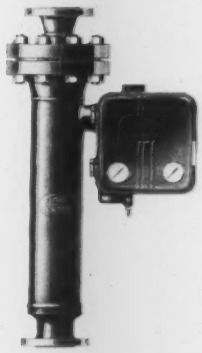
*

Little more than a speck in the Gulf of Mexico, a separator platform must hold all the equipment necessary to serve a number of producing wells. There just isn't room for extensive stock of replacements. It takes a launch at least 5½ hours to make a 60-mile trip; a helicopter at least 45 minutes. Under these conditions controls have to stand up day after day and week after week. That's why Fisher Level-Trols are chosen for offshore operations as well as for liquid level control applications throughout the world.

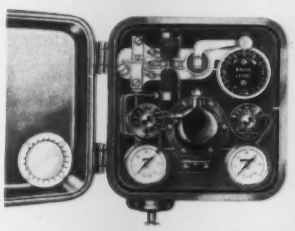
FISHER LEVEL-TROLS®

for accurate, trouble-free liquid level control on a wide range of applications . . . .

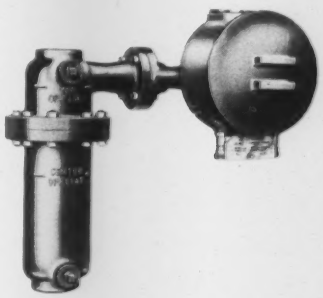
THREE BASIC CONTROLLERS



THE POPULAR TYPE 2500 PROPORTIONAL CONTROLLER—This compact and economical liquid level controller provides a proportional band adjustment up to 100%. It is pneumatically operated and level position is manually adjustable for quick, simple selection of set point. The 2500 is suitable for 3 to 15 psi or 6 to 30 psi output ranges. Controller action easily reversed in the field. Available in all styles of mountings and housings and in displacer lengths 14″ through 120″.



TYPE 2502 PROPORTIONAL RESET CONTROLLER—This Level-Trol includes, in the same size case, all the features of the Type 2500, plus reset action. It, therefore, brings the set point back, automatically to its original position and assures absolutely stable control. Proportional band adjustable to 200% and reset rate is adjustable from .005 to 1 minute per repeat.



TYPE 2300 ELECTRONIC CONTROLLER—Explosion-proof design for hazardous locations. External adjustments for proportional band (10 to 100%) and liquid level set point. Mounts on standard Level-Trol housings. Available for output DC signals 1 to 5 ma, 4 to 20 ma or 10 to 50 ma. Has plug-in converter with printed circuit. For more information on Fisher Level-Trols write to:

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / Rochester, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIP. CO., CORAOPOLIS, PA.

If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER® *Controls* SINCE 1880

EIME Traveling Instrument Exhibit

NEW YORK, N. Y.—The second annual Electronic Instrument Manufacturers' Exhibit, a traveling technical show, featuring the latest developments of seven of the nation's leading instrument manufacturers, will be held this fall at seven key sites in the east. Products are not only complementary to each other, but scientifically related.

This year's show will be under the sponsorship of General Radio Company, West Concord, Mass.; Lambda Electronics Corp., College Point, L. I.; Non-Linear Systems, Inc., Del Mar, Calif.; Panoramic Electronics, Inc. (formerly Panoramic Radio Products Co., Inc.) Mt. Vernon, N. Y.; Sensitive Research Instrument Corp., New Rochelle, N. Y.; Tektronix Inc., Portland, Ore.; and Trio Laboratories, Inc., Plainview, L. I., N. Y.

The seven touring-exhibit areas will be:

Northern New York; Syracuse, N. Y. (Sheridan Inn, Sept. 21; 12 to 7 PM); Connecticut; Norwalk, Conn. (Norwalk Motor Inn, Sept. 25, 12 to 7 PM); Long Island: Roosevelt Field, L. I. (Sagamore Room, Sept. 27-28, 12 to 8 PM); Northern New Jersey: Cedar Grove, N. J. (The Towers, October 2, 12 to 7 PM); Pennsylvania: Philadelphia, Pa. (Bellevue-Startford, Oct. 3-4, 12 to 8 PM); Central New Jersey: Watchung, N. J. (Wally's Tavern, Oct. 9, 12 to 7 PM); and Washington, D. C. (Marriott Hotel, Oct. 11, 2 to 9 PM.)

INDUSTRIAL ELECTRONICS SYMPOSIUM, jointly sponsored by IRE/PGIE, AIEE, and ISA will be held in Boston's Bradford Hotel September 20 and 21, 1961, stressing electronic-manufacturer/industrial-user cooperation.

LEEDS & NORTHRUP (4901 Stenton Ave., Phila. 44, Pa.) has installed a computer at the Bergen, N. J., generating station of Public Service Electricity and Gas Company. Computer is design to provide more efficient plant operations for the utility.

ROCKETDYNE Div. of North American Aviation has developed a more accurate method of calibrating flowmeters. Named the Volumetric Flowmeter Calibrator, the system has been licensed for production and sale to Norlac Engrg. and Mfg. Company, Culver City, California.

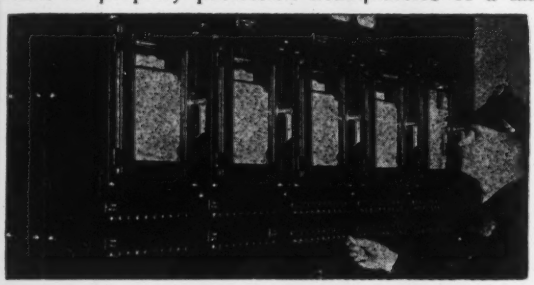
SUPERIOR TUBE CO. now furnishes hypodermic needle tubing of only 0.032″ OD and 0.20″ ID to connect a standard resistance wire and a thermostatic wire (indicated by arrow in inset) in Trig-R-Heat soldering guns produced by P. Wall Mfg. Co. Grove City, Pa. (Superior Tube Co., Norristown, Pa.)

Foundation Supports Laboratory Apparatus Development Program

WASHINGTON, D. C.—National Science Foundation has made 56 grants totaling $716,400 to mathematicians, scientists, and engineers who at various colleges and universities will develop apparatus to help modernize instruction in their fields in schools and colleges throughout the country.

The program does not provide money for purchase of equipment for use by an individual school or college, nor for the development of equipment solely for local use. The objective is to aid competent scientists to develop new equipment that schools and colleges throughout the country will find useful. Grantees are expected to supply teachers with full information about apparatus they devise, and ways to use it in teaching, through reports, articles in professional journals, and presentations at professional meetings.

ESTERLINE ANGUS INSTRUMENT CO. (Box 596, Indianapolis 6, Ind.) furnished and installed Event Recorders in property protection headquarters of a large

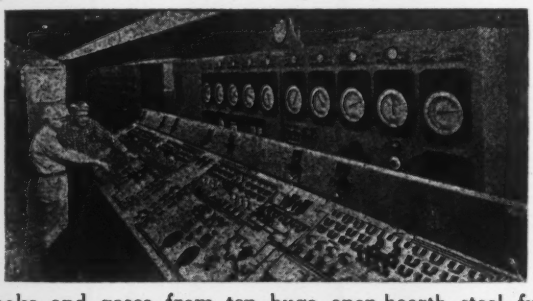


Indiana plant where the guard's tours, the fire alarm system, the sprinkler system, railroad siding gates, and a first aid station are monitored from a panel.

MINNEAPOLIS-HONEYWELL Special Systems Div., Pottstown, Pa., has received an order to supply a computer-directed control system to Celanese Corp. for its new multi-million-dollar acetyl manufacturing plant being built at Bay City, Tex.

TRW COMPUTERS CO. furnished the computer controllers for the world's largest basic oxygen steel furnaces plant of Great Lakes Steel in Detroit, a division of National Steel Corporation.

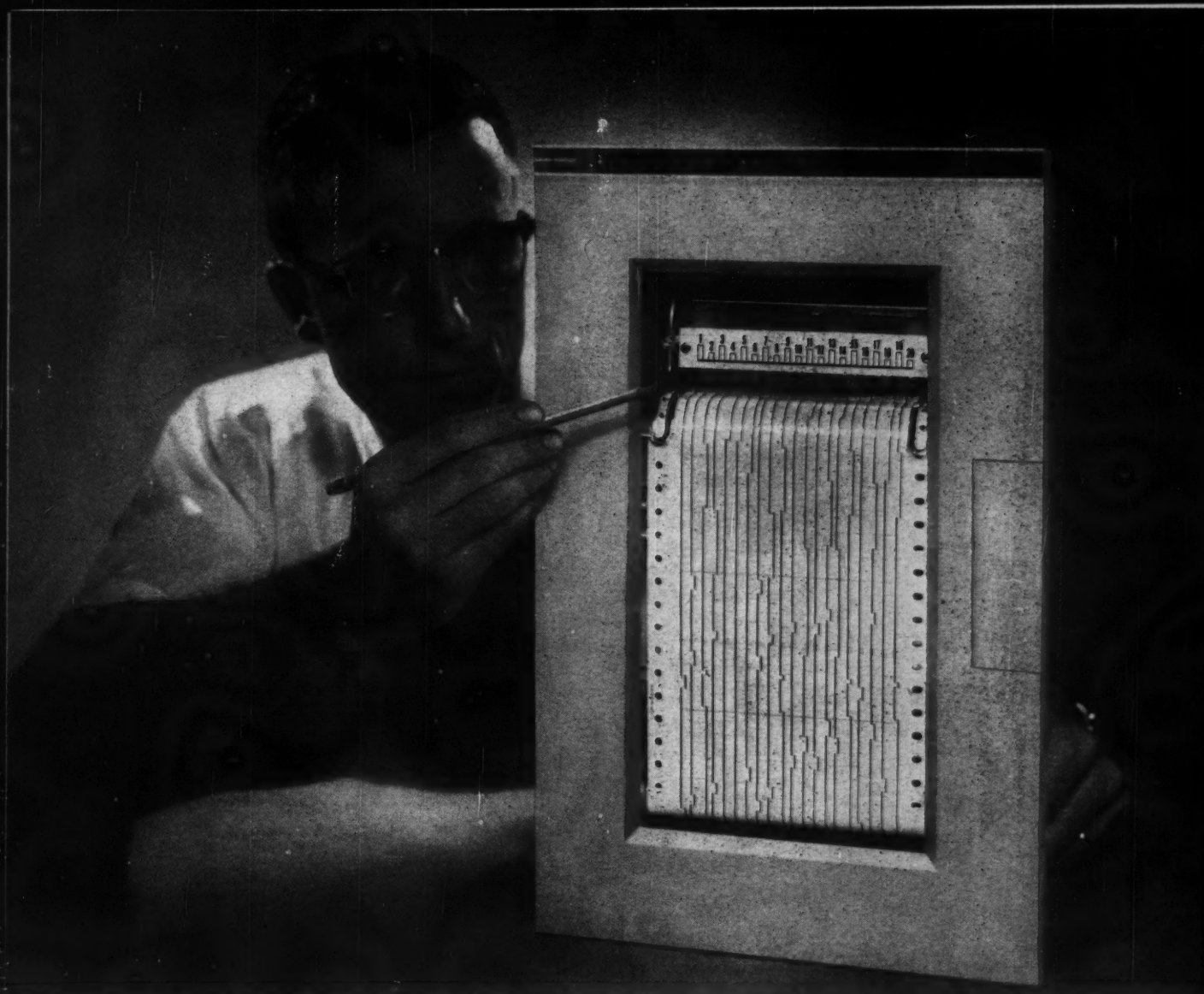
RESEARCH-COTTRELL has furnished electrical precipitators and an automation system for the control of



smoke and gases from ten huge open-hearth steel furnaces at U. S. Steel Corporation's Geneva plant in Utah. Flow control is exercised from console.

← CIRCLE 29 ON READER-SERIVCE CARD

CIRCLE 30 ON READER-SERVICE CARD →



Available now in either 10-channel or 20-channel model

"620" Esterline Angus Recorder with Tempen*

Instead of ink, the new "620" Event Recorder with Tempen uses *electrically-heated styluses of stainless steel.* Torture testing reveals they will endure 20 years of continuous operation and still respond in less than 1/20 of a second!

The "620" also uses special chart paper with a non-wax finish, eliminating the danger of marred records caused by external heat, rough handling or discoloration from strong light.

Adaptable to hundreds of research, production and maintenance uses, the "620" can reveal the productive and non-productive time of any or all machines in a plant. Still other uses include circuit breaker action, psychological testing, qualitative analysis and conveyor operation.

Economically priced, the new "620" with Tempen is another versatile product of Esterline Angus master craftsmen.

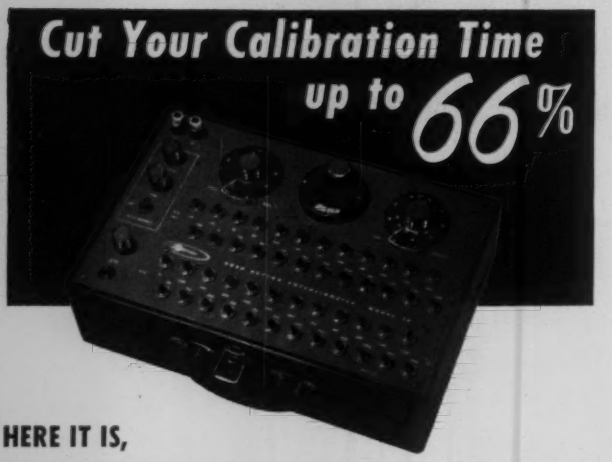
For more detailed information, write for new "620" with Tempen descriptive folder. Address: ESTERLINE ANGUS INSTRUMENT COMPANY, INC., Box 596G, Indianapolis 6, Indiana.

Visit us at ISA Show, Space 504
Los Angeles • September 11-15

*new event recorder with *inkless* method of writing . . . operates more than 50 days without a change in charts

Excellence in graphic recording for over 50 years—ESTERLINE ANGUS

Cut Your Calibration Time up to 66%



HERE IT IS,

a fast, accurate and fool-proof method of calibrating thermoelectric type instruments. The 5P*—Portable, Precision, Preset Pushbutton, Potentiometer—combines the latest design advances with pushbutton simplicity to give you the newest and easiest to operate calibrating device available.

No other calibrating method offers such speed and reliability.

SPECIFICATIONS

ACCURACY:
Within 0.1 percent of nominal output, or 10 microvolts, whichever is greater.

STABILITY:
Within 0.01 percent of nominal output per year.

TEMPERATURE RANGE:
Any two of the ranges listed in Table (others by request).

RESOLUTION:
(1) Reference junction compensation —
0.002 microvolts at marked graduations.
0.008 microvolts between graduations (equiv. output).
(2) Standardizing — 0.001 microvolts (equivalent output).

EXT. RESISTANCE COMPENSATION DIAL:
0 to 20 ohms.

REF. JUNCTION COMPENSATION:
From 0 to 40 Deg. C.
(30 to 105 Deg. F)

INTERNAL RESISTANCE:
(1) Potentiometer calibration
15-20 ohms (fixed)
(2) Pyrometer calibration
1-100 ohms (adjustable)

RATED OVERLOAD TOLERANCE:
500 percent for 30 seconds (Potentiometer or pyrometer calibration)

RECOVERY FROM RATED OVERLOAD:
(1) Potentiometer calibration—
0.5 seconds.
(2) Pyrometer calibration—
5.0 seconds

DIMENSIONS:
Approximately 15 in. long x 10 in. wide x 6 in. high (overall)

WEIGHT:
Approx. 14 lb.

STANDARD RANGES

Thermo-Couple Type	Copper-Constantan		Iron-Constantan (N. B.S.)		Iron-Constantan (Bd.)		Chromel-Alumel		Platinum-Plat./Rho. (10%)		Platinum-Plat./Rho. (13%)	
	Deg C	Deg F	Deg C	Deg F	Deg C	Deg F	Deg C	Deg F	Deg C	Deg F	Deg C	Deg F
	-120	-190	-50	-60	-50	-60	0	0	0	200	0	200
	-100	-125	-40	-20	-40	-20	50	200	200	400	200	400
	- 80	-100	-20	0	-20	0	100	300	300	600	300	600
	- 60	- 75	0	20	0	20	150	400	400	800	400	800
	- 40	- 50	20	40	20	40	200	500	500	1000	500	1000
	- 20	- 25	40	80	40	80	250	600	600	1100	600	1100
T	0	0	60	120	60	120	300	700	700	1200	700	1200
E	20	25	80	160	80	160	350	800	750	1300	750	1300
M	40	50	100	200	100	200	400	900	800	1400	800	1400
P	60	75	120	240	120	240	450	1000	850	1500	850	1500
E	80	100	140	280	140	280	500	1100	900	1600	900	1600
R	100	125	160	320	160	320	550	1200	950	1700	950	1700
A	120	150	180	360	180	360	600	1300	1000	1800	1000	1800
T	140	175	200	400	200	400	650	1400	1050	1900	1050	1900
U	160	200	220	440	220	440	700	1500	1100	2000	1100	2000
R	180	225	240	480	240	480	750	1600	1150	2100	1150	2100
E	200	250	260	520	260	520	800	1700	1200	2200	1200	2200
	220	275	280	560	280	560	850	1800	1250	2300	1250	2300
	240	300	300	600	300	600	900	1900	1300	2400	1300	2400
	260	325	320	640	320	640	1000	2000	1350	2500	1350	2500
	280	350	340	680	340	680	1100	2100	1400	2600	1400	2600
	300	375	360	720	360	720	1200	2200	1450	2700	1450	2700
	320	400	380	760	380	760	1300	2300	1500	2800	1500	2800
	340	425	400	800	400	800	1400	2400	1600	2900	1600	2900
Range No.	1	2	3	4	5	6	7	8	9	10	11	12

*T.M., Orenda Engines, Ltd.

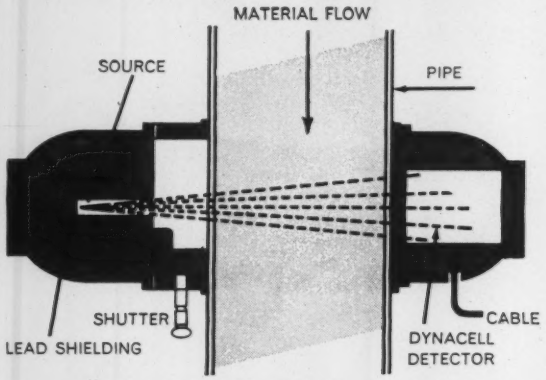
For Canadian Sales contact:
Sales and Contracts Manager, Orenda Engines, Limited
Box 4015, Terminal "A," Toronto, Ontario, Canada

THERMO-COUPLE PRODUCTS CO. INC.
701 NORTH IOWA ST. VILLA PARK, ILL

CIRCLE 211 ON READER-SERVICE CARD

ICS BRIEFS

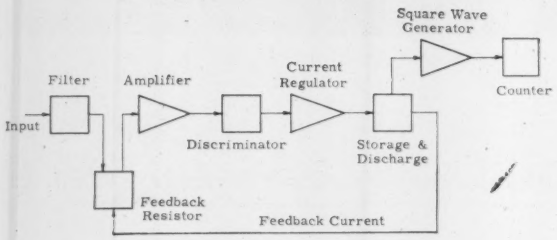
Control of Slurry Density



The new Qualicon series of Liquid Density Gauges provides continuous measurement of the density of a solution or slurry directly in a process pipe without contacting the material and without moving parts . . . Measurements are performed through the use of a cesium-137 source in the measuring head. Gamma-rays produced by the source pass through the measured material at a rate that is inversely related to its density. The gamma-rays which pass through the material are detected by the Dynacell radiation chamber and are converted into the measurement . . . (*From new 6-page bulletin and product release, Nuclear-Chicago Corp., 333 East Howard Ave., Des Plaines, Ill.*)

FOR THIS LITERATURE CIRCLE 209 ON READER-SERVICE CARD

Electronic Integrator

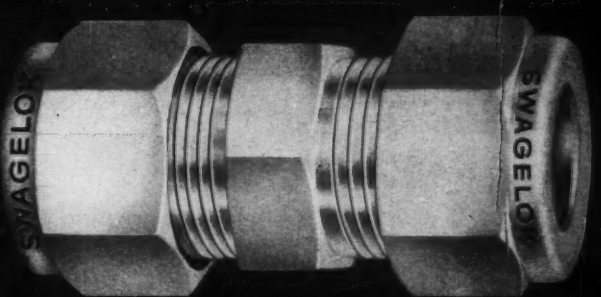


The Royson Lectrocount is an electronic integrator that operates directly from a millivolt signal . . . The difference between an input voltage and feedback voltage is impressed upon the input of a high gain chopper type amplifier operating into a discriminator and filter. This DC voltage controls the valve of a DC current output of a current regulator operating through the feedback resistor and into a storage capacitor in parallel with a discharge device. Upon discharge the pulse occuring operates a second current controller arranged to either work a relay for contact closures (slow counting rates) or furnishes a suitable voltage pulse for high counting rates. The pulse rate is made almost exactly linear with the input voltage . . . (*From new 4-page Bulletin 230, Royson Engineering Co., Hatboro, Pa.*)

FOR THIS LITERATURE CIRCLE 210 ON READER-SERVICE CARD

CIRCLE 31 ON READER-SERVICE CARD →

WHY WAS THIS TUBE FITTING MADE FROM PLATINUM?



This Swagelok tube fitting was machined from Platinum because that is what our customer needed for his nuclear reactor experiments. This is just one of many outstanding examples of Swagelok customer service. The scientist who needed this fitting knew that Swagelok tube fitting reliability would meet the exacting requirements of leak tightness for nuclear work. He also knew that full cooperation in delivering Swagelok in any machineable metal is routine.

Swagelok, the tube fitting of total dependability, can be provided in **any** machineable metal or plastic to solve your most demanding problem.

Swagelok® TUBE FITTINGS SOLVE YOUR PROBLEMS

CRAWFORD FITTING COMPANY • 884 EAST 140th St. • CLEVELAND 10, OHIO
CRAWFORD FITTINGS (CANADA), LTD. • NIAGARA FALLS, ONTARIO, CANADA

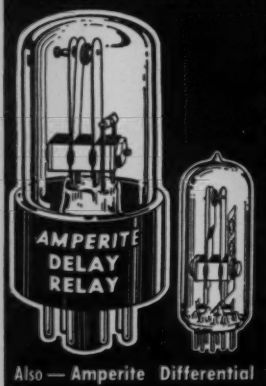
Large production gives you low prices!
– that's why...

Over 100 O.E.Ms have standardized on

AMPERITE

Thermostatic DELAY RELAYS

2 to 180 Seconds



Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.

Hermetically sealed. Not affected by altitude, moisture, or climate changes.

SPST only—normally open or closed.

Compensated for ambient temperature changes from —55° to +80° C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived,** and—**inexpensive!**

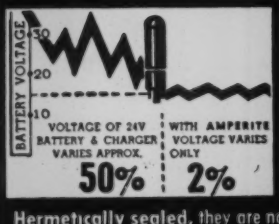
TYPES: Standard Radio Octal, and 9-Pin Miniature . . . **List Price, $4.00.**

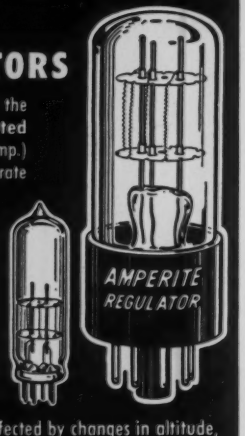
Also — **Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection.

PROBLEM? Send for Bulletin No. TR-81

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit **automatically regulated** at a definite value (for example, 0.5 amp.) . . . For currents of 60 ma. to 5 amps. Operate on A.C., D.C., or Pulsating Current.





Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—50° to +70° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . . . **List Price, $3.00.**

Write for 4-page Technical Bulletin No. AB-51

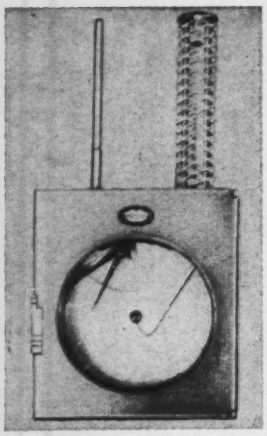
AMPERITE

561 Broadway, New York 12, N. Y. . . . . CAnal 6-1446

In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10

CIRCLE 32 ON READER-SERVICE CARD

Relative Humidity



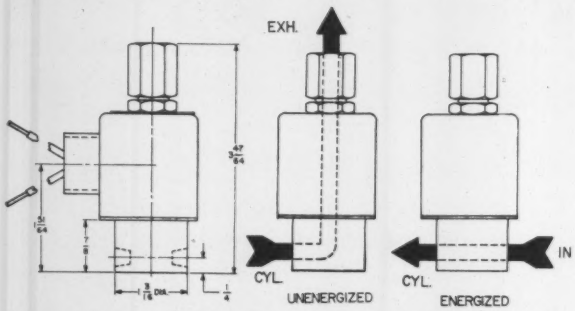
Relative humidity is the ratio of the amount of water vapor in the air to the amount of water vapor which would saturate the air at the same temperature. It is expressed as percentage of saturation (100%) . . . The *Hygrograph* uses a hair element consisting of specially selected and treated human hairs to record directly, through a low friction linkage, the relative humidity in the air. The hair element lengthens as the humidity increases and shortens as the humidity decreases. The linkage converts the non-linear expansion of the hair element into linear movement at the recorder pen, making possible the use of a chart uniformly graduated from 0 to 100%. The instrument will record relative humidity between 20% and 90% with an accuracy of 5% . . .

The *Thermo-Hygrograph* is a two pen recorder designed for the simultaneous recording of temperature and relative humidity on the same chart, for comparison purposes. It is equipped with a highly sensitive and accurate mercury actuated temperature system plus the relative humidity system used in the Hygrograph . . . (*From new 28-page Catalog 625, of temperature, pressure, relative humidity, time-of-operation recorders, Weksler Instruments Corp., 195 East Merrick Rd., Freeport, L.I., N. Y.*)

FOR THIS LITERATURE CIRCLE 213 ON READER-SERVICE CARD

Miniature Solenoid Valve

A new design that improves the flux path and heat dissipation of the solenoid valve has made it possible to reduce the overall size of this quiet and cool operating



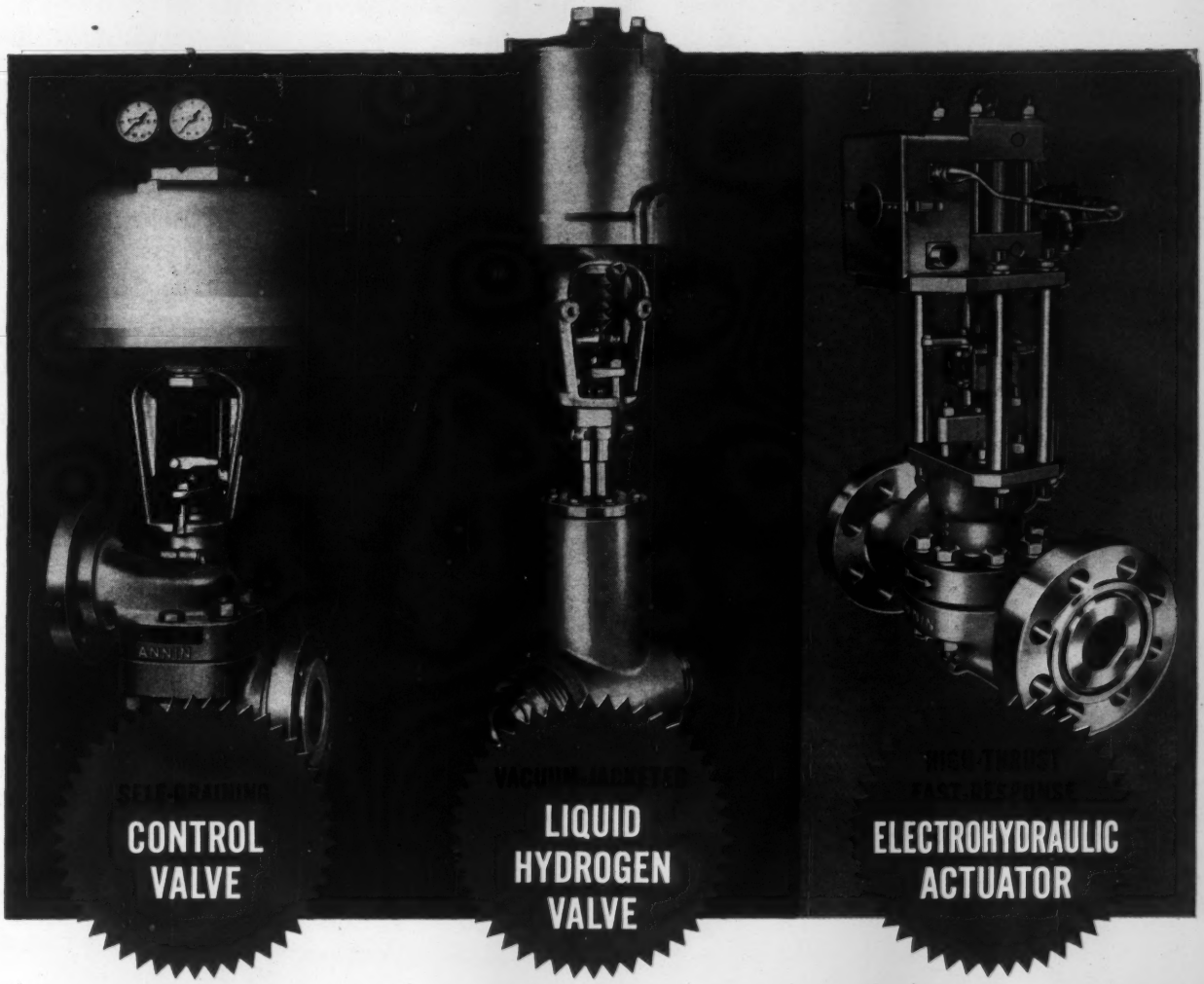
valve while maintaining the same flow capacity and working pressures ranges of larger conventional 3-way solenoid valves . . . Packless construction and the use of only two moving parts in the BM-300 reduce maintenance problems to an absolute minimum. Valve is bubble-tight to internal or external leakage, and special models are available for not over one micron leakage . . . (*From new 2-page Product Release, Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.*)

FOR THIS LITERATURE CIRCLE 214 ON READER-SERVICE CARD

(*Continued on page* 1376)

ANNIN VALVES ...offer advanced designs for fields that are moving ahead!

MILITARY AND PROCESS CONTROL APPLICATIONS



In design and capability, Annin Control Valves **begin** where others leave off. The reason? Annin has always set the pace in fluid flow control, ever since it pioneered split body, single seat construction, and showed the industry how to achieve precise, positive control automatically. Typical of Annin's leadership today in fields requiring advanced design, are the three new valves pictured above: Model 1900 Self-Draining Control Valve, designed to drain the line and valve body of flowing media which may be corrosive, toxic or may tend to set up in the system; Model 1700 Vacuum Jacketed Liquid Hydrogen Valve for missile ground support systems; and Series 20000 Electrohydraulic Actuator characterized by high thrust and extremely fast response. See these, and other Annin products, including the standard split body valve line, in booths 1044-1048 at the 16th Annual Instrument-Automation Conference and Exhibit.

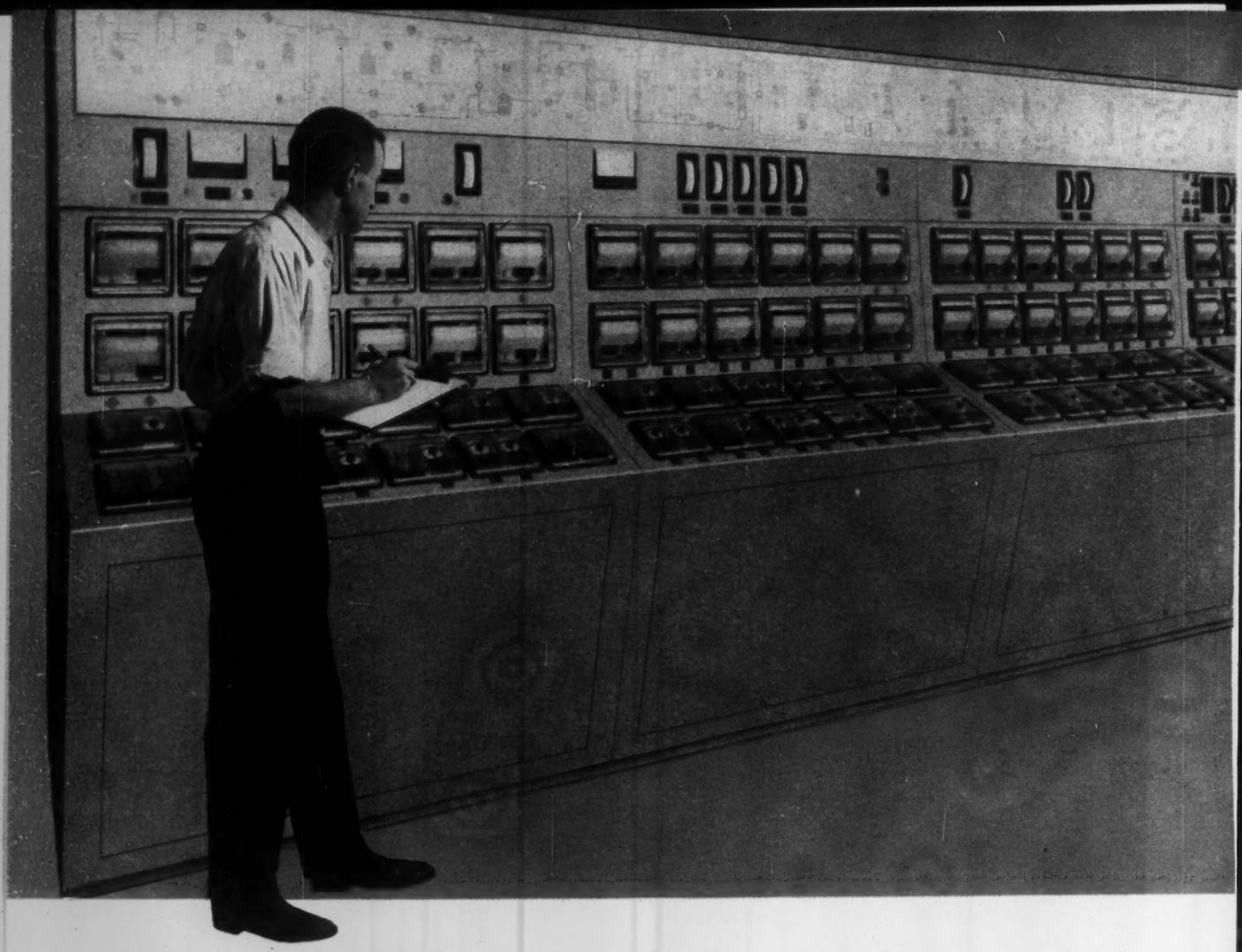
You are cordially invited to visit Annin's Los Angeles plant while visiting the Instrument Show. Inquire for transportation at the display booth.

ANNIN VALVES

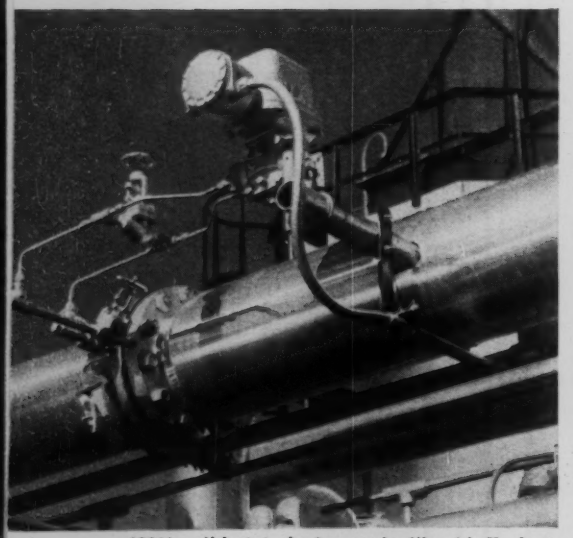
Products that work for your profit

THE ANNIN COMPANY
1040 S. Vail Avenue • Montebello, California

CIRCLE 51 ON READER-SERVICE CARD



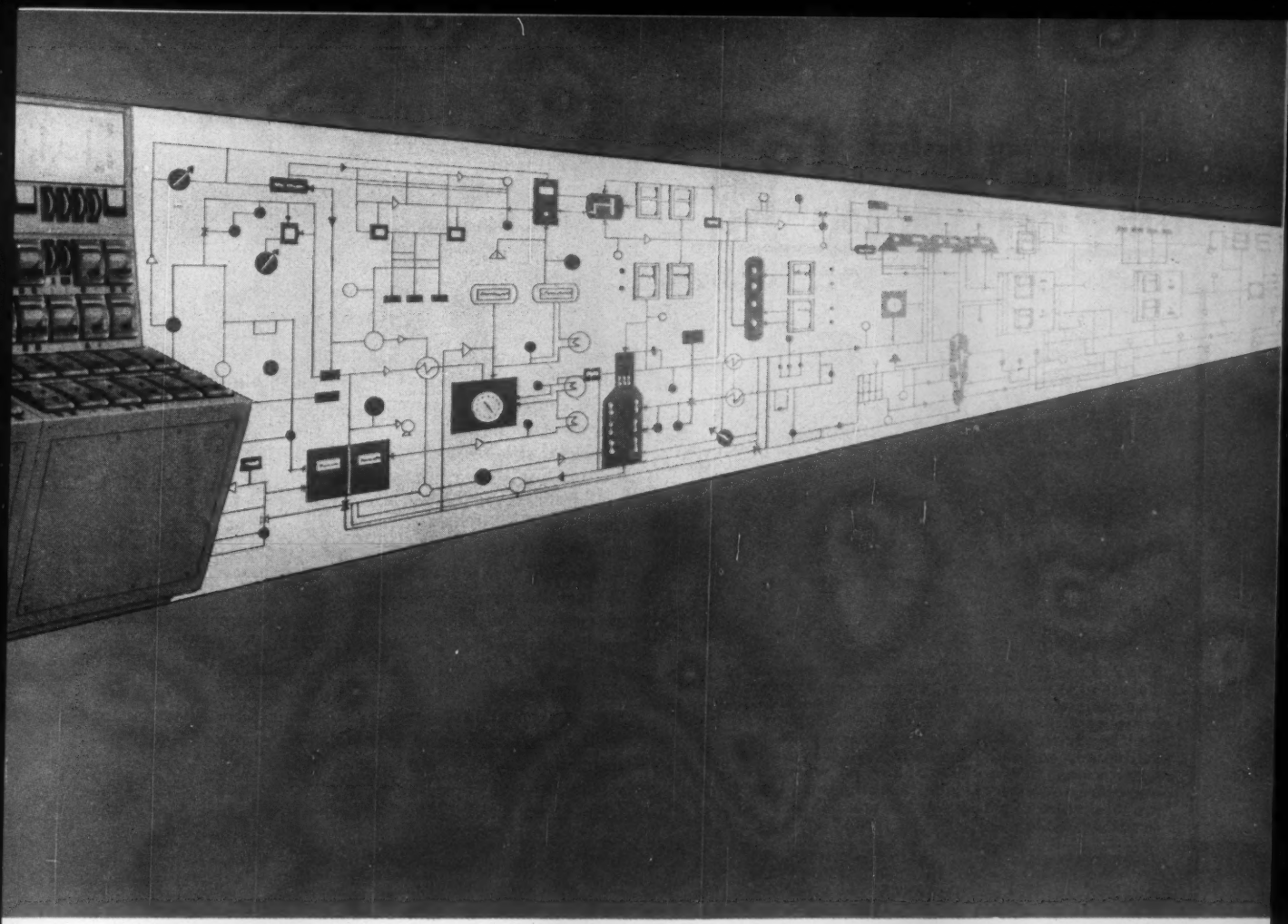
Foxboro Electronic Consotrols* shrink



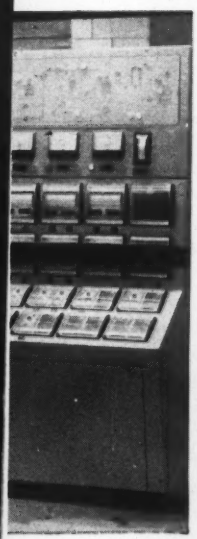
100% solid state instruments, like this Foxboro Type 613 d/p Cell* Flow Transmitter, were used in all control loops to assure instant transmission over long distances. **Reg. U. S. Pat. Off.*

Fifteen-foot Foxboro Electronic Console permits fast scanning of instruments — gives dependable control of Alkar† unit, styrene plant, and steam plant for Cosden Petroleum.

†Universal Oil Products Co. — Process Licensor
Badger Manufacturing Co. — Contracting Engineers



panel length 66% for Cosden Petroleum



Panel planned for 45 feet, then reduced to 15 feet with Foxboro "small case" Electronic Consotrols

Space saving has taken on a new meaning at Cosden Petroleum Corp. At Cosden's Big Spring, Texas refinery, an Alkar unit, a styrene plant, and a steam plant are all electronically controlled by one 15-foot Foxboro Modular Console.

When Cosden Petroleum specified Foxboro "small case" Electronic Consotrols and modular consoles, 30 feet of panel space were eliminated for a considerable saving in building construction costs alone.

What's more, Foxboro packed 61 Electronic Consotrol Controllers, plus 100 indicating and recording points into the 15-foot panel — and there's still room to spare for tomorrow's instrumentation needs! Spare panel cut-outs for 35 more controllers and 9 more recorders are pre-wired and ready for service. All Cosden needs to do is hook up the transmitter leads at the bottom of the cabinet and slip the recorder or controller into the panel.

Maintenance men also like the easy way they can transfer instruments on the modular console. Instruments slide in and out of their housings as easily as drawers. A simple plug-in connection puts the instruments into action.

You too, can save space, save time, save money — with Foxboro Electronic Consotrols.

Write for Bulletin 9-12. The Foxboro Company, 467 Norfolk Street, Foxboro, Massachusetts.

**Reg. U. S. Pat. Off.*

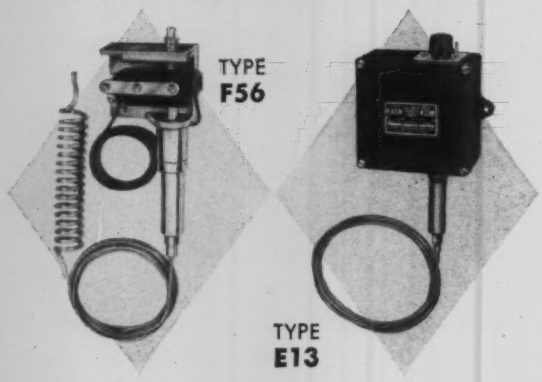
FOXBORO

REG. U.S. PAT. OFF.

Improved Design

REMOTE BULB TEMPERATURE CONTROLS **F56 E13**

WIDE RANGE CALIBRATED



The F56 and E13 are functionally similar controls. Type F56 is a wide range, uncalibrated, skeleton unit designed for use in ovens, incubators, and other applications where space or weight is a limiting factor. Type E13 is a narrow range, calibrated, enclosed unit intended for similar applications but under conditions where an enclosure and external adjustment knob and dial are desirable. Explosion proof unit, Type E98, is also available.

Temperature Ranges	F56 . . . up to maximum limits of −150° to +150°F, 70° to 370°F, or 100° to 650°F. E13 . . . 100° or 200° spans between −150° and +650° F limits.
Switch Ratings	15 or 20 amps at 115 or 230 volts AC. DC switches also available.
Switch Types	N.O., N.C., or Double Throw, no neutral position.
Adjustments	F56 . . . slotted range adjustment screw on top, uncalibrated settings. E13 . . . external knob and pointer, calibrated settings.
Electrical Connections	F56 . . . 12-inch lead wires attached directly to switch terminals. E13 . . . to internally located terminal block via conduit opening in enclosure.
Capillary Tube Length	6-foot standard length. Other lengths available.
Mounting	E13 . . . surface mounted in any position by means of dog ears. May be flush mounted. F56 . . . Surface mounted in any position by holes drilled in base of bracket. May be flush mounted.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure and vacuum controls. Standard units can be modified or custom-built units made to your specifications. Additional information on temperature controls is available upon request.*

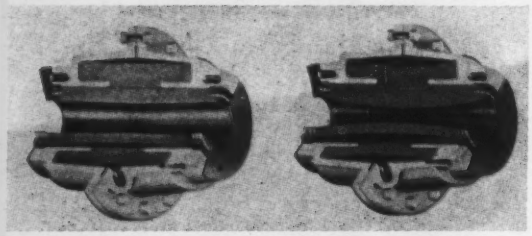
UNITED ELECTRIC

CONTROLS COMPANY

85 School St., Watertown, Mass.

CIRCLE 35 ON READER-SERVICE CARD

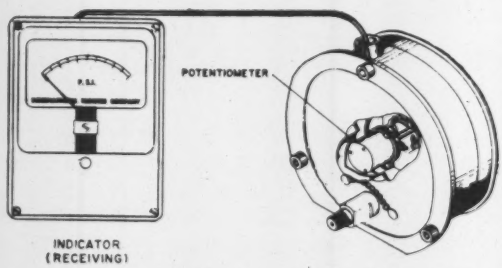
Slurry Valve



An automatic control adaptation for the C Valve . . . will enable its convenient use with any 3 to 15 psi pneumatic control instrument . . . The basic components of this control package are an air-driven hydraulic pump complete with reservoir, a pilot operator for controlling the pressure to the valve in a ratio to a 3 to 15 psi control signal from the controller, and the appropriate size Clarkson C Slurry Valve. In such a control package, one hydraulic pump unit is sufficient to supply a number of valves, and for each valve a pilot is necessary. Because of the fact that the internal parts of the Clarkson C Valve are of rubber, the hydraulic medium recommended to be used in this system is water . . . Although complete, tight closure of the Model C Valve is possible, the design characteristics of this valve are such that the valve operates as a variable Venturi in the range from full open to a 50 percent reduction in diameter . . . The clean flow characteristics . . . are amply evident . . . A cut-away view of the valve in the wide-open position (left) illustrates the fact that the valve is merely an equivalent length of pipe in this position. A cut-away view of the valve with a 50 percent reduction in diameter, is shown (right). In this position, the flowing material is being throttled through the center of the valve, while the smooth configuration practically eliminates the possibility of either build-up or plugging, while ensuring a minimum abrasion . . . (*From General Bulletin* 10.0-1, *Clarkson Co.*, 735 *Loma Verde Ave., Palo Alto, Calif.*)

FOR THIS LITERATURE CIRCLE 215 ON READER-SERVICE CARD

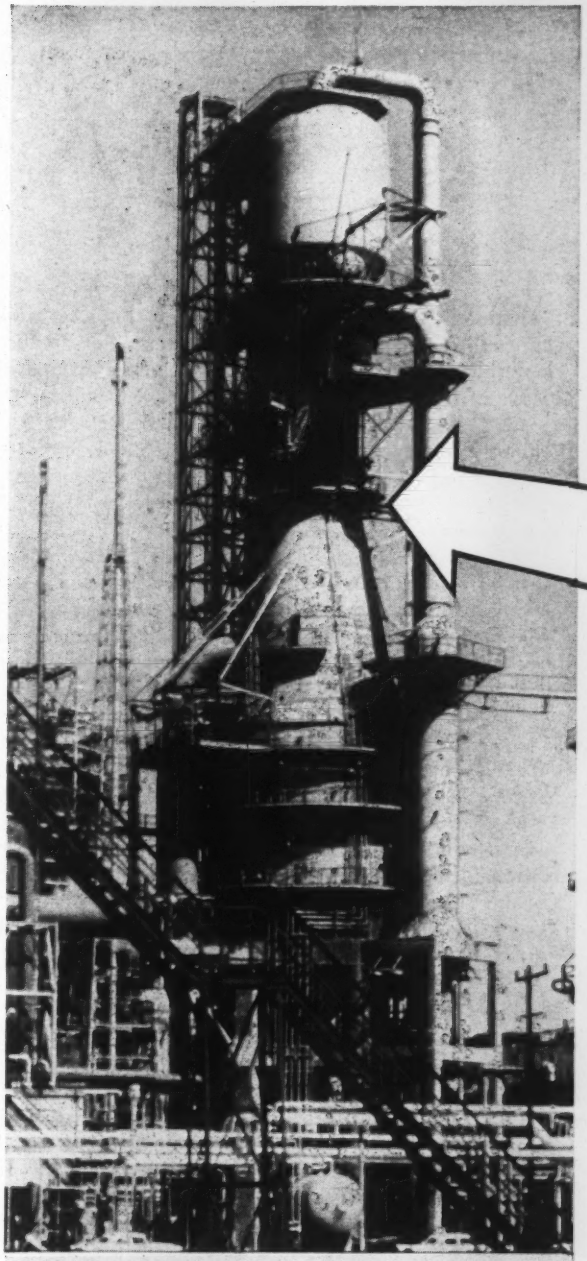
Electric Pressure Transmitter



The Electric Transmitter is a standard Acragage with an extended pinion shaft in the movement, connected to a low torque potentiometer. The motion of the Bourdon tube, converted to rotary motion by the gage movement, positions the brush member on the resistance element in the potentiometer. The resultant change in resistance is instantly signaled to the receiving indicator. This signals results in a pressure indication of the receiver identical with the actual pressure measured at the transmitter . . . (*From new* 40*-page Catalog G, Robertshaw-Fulton Controls Co., Fulton Sylphon Div., Knoxville* 1, *Tenn.*)

FOR THIS LITERATURE CIRCLE 216 ON READER-SERVICE CARD

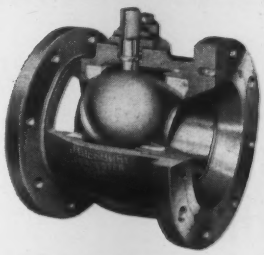
At *CRITICAL* Valve Control Points



...You Get Dependable Operation with

jamesbury "Double-Seal"™ BALL VALVES*

*PATENTED



WIDE RANGE OF SIZES:

Screwed end ¼" through 3".

Flanged 150# series ½" through 12" — 300# ½" through 8".

Larger sizes on request.

VARIETY OF MATERIALS:

Valves in 303 and 316 Stainless Steel, Alloy 20, Carbon Steel, Bronze, Ductile Iron, Monel, Aluminum and PVC. Interchangeable seats and seals in Teflon, Teflon compounds, Nylon, Buna-N, Neoprene, Hypalon and natural rubbers. Type DZ: Ductile Iron and Carbon Steel, Standard.
Other materials on request.

FIRE SAFE VALVING IN REFINERIES

The Jamesbury "Double-Seal" FIRE SAFE Ball Valve (Type DZ) has been accepted for use in the hydrocarbon industry because of its outstanding performance. In the event of fire — and the loss of the valve's soft seats, secondary metal seats provide effective shut-off of the fluid flow.

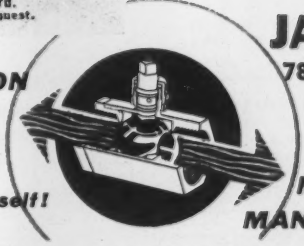
It stands to reason that a valve that performs outstandingly under adverse conditions can be relied on to give trouble-free performance under less severe conditions. That has been one of the big reasons, at least, for the success of Jamesbury "Double-Seal" Ball Valves. Proved dependable at *critical* valve control points, these valves have gone into industrial plants everywhere to control nearly all types of media flow.

There are many exclusive features about the Jamesbury "Double-Seal" Ball Valve which contribute to its excellent performance record. For example, there's Jamesbury's patented lip seal; there are no internal springs; you get leak-tight stem seals; operators are mounted integral with the valve. For further information about Jamesbury "Double-Seal" Ball Valves, contact your nearest stocking distributor — or write us direct.

Ask For Jamesbury Fluid Services Guide

JAMESBURY CORP.
78 New Street, Worcester, Mass.
DISTRIBUTORS IN PRINCIPAL CITIES

QUARTER TURN OPERATION
HIGH FLOW CAPACITY
ZERO LEAKAGE



NO LUBRICATION REQUIRED
MINIMUM MAINTENANCE
MANUAL OR POWER OPERATION

As Versatile As Industry Itself!

74-1 ©Jamesbury Corp 1961

CIRCLE 36 ON READER-SERVICE CARD

NEW *Martin-Decker* **Precision Test Gauge** *makes pressure readings* **25% More Accurate**

8½" Dia. Dial—25.13" Scale Length
12" Dia. Dial—36.91" Scale Length

- **Big scale readings in small scale space!**
- **Greater Accuracy!**
- **Requires less panel space!**

360° Calibration makes Martin-Decker Scale 25% longer—gives 25% greater readability than models with 270° scale.

Ni-Span C Bourdon tube is temperature-stable, corrosion-resistant—superior to other alloys.

Tube tip bleed is standard equipment.

Movement calibrated to dial, with an accuracy of ± 0.15% or better.

Uniform linear increments. Protected front zero adjust.

Capacities from 60 PSI to 15,000 PSI.

Find out why more and more O.E.M. designers specify Martin-Decker Precision Test Gauges for measuring gas and fluid pressures.

MARTIN DECKER

Precision Pressure Instruments Testing—Weighing—Load and Force Measurement

Write for Technical Brochure T-58

MARTIN DECKER PRECISION TEST GAUGES

MARTIN-DECKER CORPORATION • 3431 Cherry Ave., Long Beach 7, Calif.
SEE OUR BOOTH 947 AT ISA SHOW
CIRCLE 37 ON READER-SERVICE CARD

NEW NEW NEW NEW NEW NEW NEW NEW NEW

when it **MELTS**

you know the *temperature!*

NEW *Markal* **THERMOMELT** TEMPERATURE INDICATORS

With Handy Adjustable Holder

The easy modern way to determine exact working temperatures!

Just mark or stroke the surface with THERMOMELT . . . when it reaches the desired temperature, the mark liquefies. There's no guesswork, no wasted time or material . . . THERMOMELT is the quick, precise way to determine heating temperatures. Accurate to within ±1%.

A Stik For Every Temperature from 113° F. to 2000° F.

SEND TODAY for free THERMOMELT literature and pellet sample (indicate temperature desired).

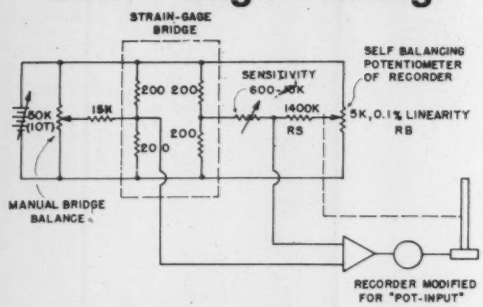
ALSO AVAILABLE IN LIQUIDS AND PELLETS for inaccessible or hard-to-measure applications. Wide range of temperatures.

Made by the Manufacturers of Markal Paintstik Markers and Protective Coatings.

MARKAL CO. See us at the I.S.A. Show . . . Booth 216
3080 West Carroll Avenue • Chicago 12, Illinois

CIRCLE 38 ON READER-SERVICE CARD

Strain Gage Plotting



There are three general methods of coupling strain gages to Moseley Autograf X-Y recorders. Two of these employ DC, and the third employs AC bridge excitation.

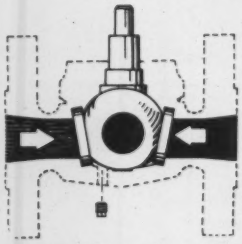
(1) In the direct measurement of bridge output voltage, the simplest arrangement, the recorder acts as a voltmeter and measures the voltage developed across the output terminals of the bridge. With the usual bridge of a few hundred ohms, useable output voltages of the order of 5 to 30 millivolts are obtained . . .

(2) With suitable modification to the recorder input circuits, the strain gage and the recorder balancing system may be excited from a common DC power supply . . . This method offers great stability and eliminates inaccuracy due to relative drift of two separate DC voltage sources. It is recommended this modification be made at the factory . . .

(3) The use of AC bridge excitation is often the choice depending on the particular conditions. Certain Moseley Autograf recorders can be furnished with either axis wired for use with a 60 cps AC strain gage bridge system. It is obvious that the AC system permits the use of transformer windings in many combinations and thus an almost infinite variety of circuits is possible . . . (*From new 4-page Application Note AN*103, *F. L. Moseley Co., 409 North Fair Oaks Ave., Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 217 ON READER-SERVICE CARD

Flo-Ball Valves

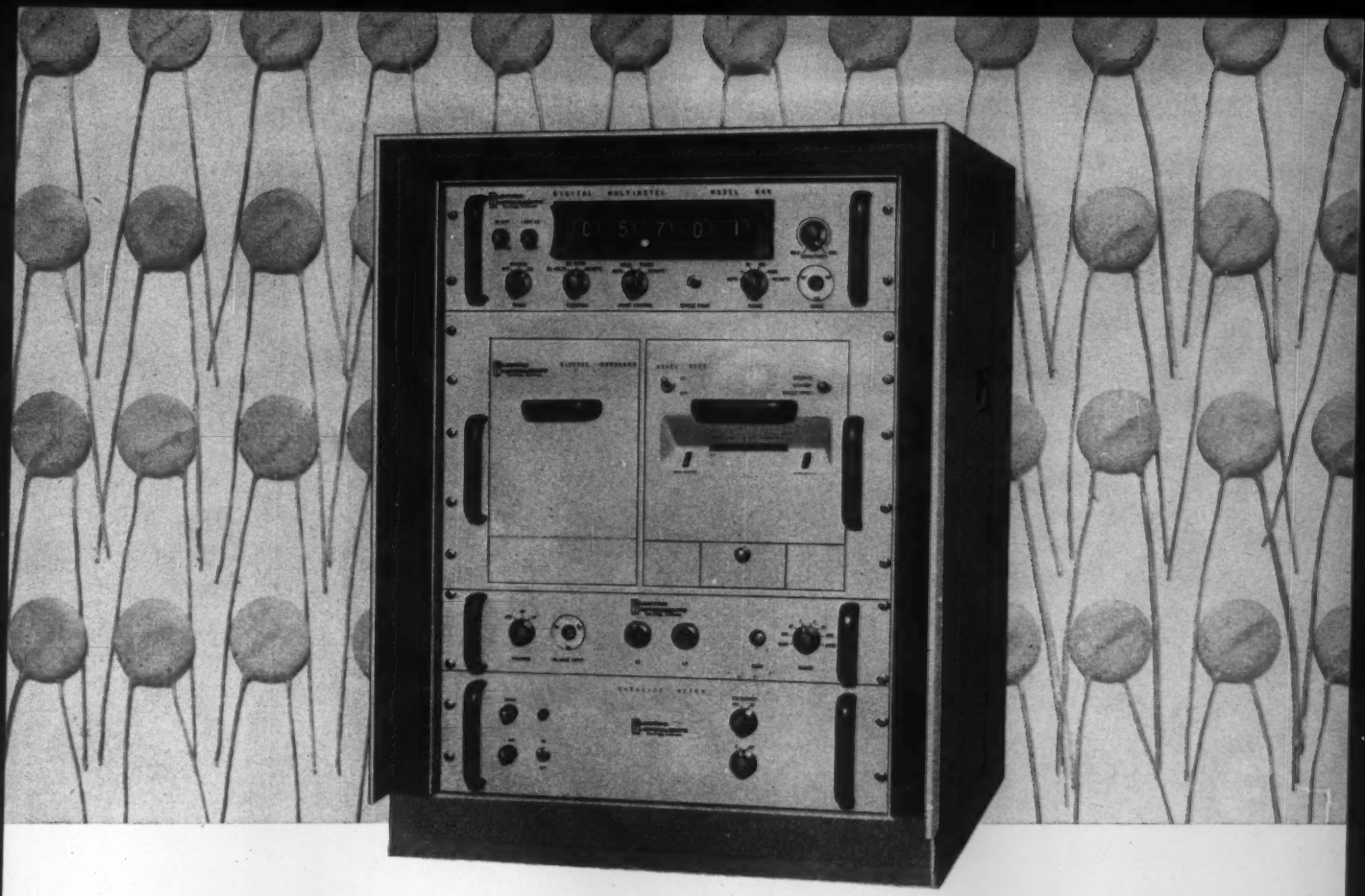


Flo-Ball offers all of these features: (1) Top entry—all internal parts can be removed and re-installed without removing valve from line. (2) Top and bottom guided ball—provides truly double seal, extends seat life. Makes for easy operation. (3) Double seats—interchangeable and replaceable seats insure sealing in both directions; give double protection against leakage. (4) Flanges integral with body—rugged, one-piece body design gives greatest possible strength. (5) One piece ball and stem—no possibility of separation of ball from stem. Always perfect alignment with zero backlash. Foolproofed for assembly. (6) Block and bleed—top and bottom guided ball and floating seats provide simultaneous upstream and downstream seal . . . a true block and bleed valve. Block and bleed type available on special order . . . (*From new 16-page catalog, Hydromatics, Inc., Bloomfield, N. J.*)

FOR THIS LITERATURE CIRCLE 218 ON READER-SERVICE CARD

(*Continued on page* 1382)

CIRCLE 39 ON READER-SERVICE CARD →



Now measure direct capacitance at 60 readings per minute, dissipation factor to 0.1%!

Capacitors in production quantities can now be tested quickly and accurately with the new high speed, all electronic, EI Model 6150 Digital Capacity Meter.

Capacitance or dissipation factor is automatically measured at 60 readings per minute and higher, and the result digitally presented both visually and in coded form for direct driving of printing devices. Readings are actual values. Possibility of human error has been reduced to a minimum.

Completely Automated Systems—The EI Model 10003 Capacitance Monitoring System, shown above, combines the Model 6150 with a digital printer to provide a simple, low priced, automatic capacitance measuring system.

Applications include production lines of capacitor manufacturers, military component evaluation programs, receiving inspection test areas and other uses where large quantities of capacitors must be tested quickly and accurately.

Ask your nearest EI field engineer for complete information on the new EI Capacity Meter. He is thoroughly qualified to help with your component testing problems.

MODEL 6150 SPECIFICATIONS

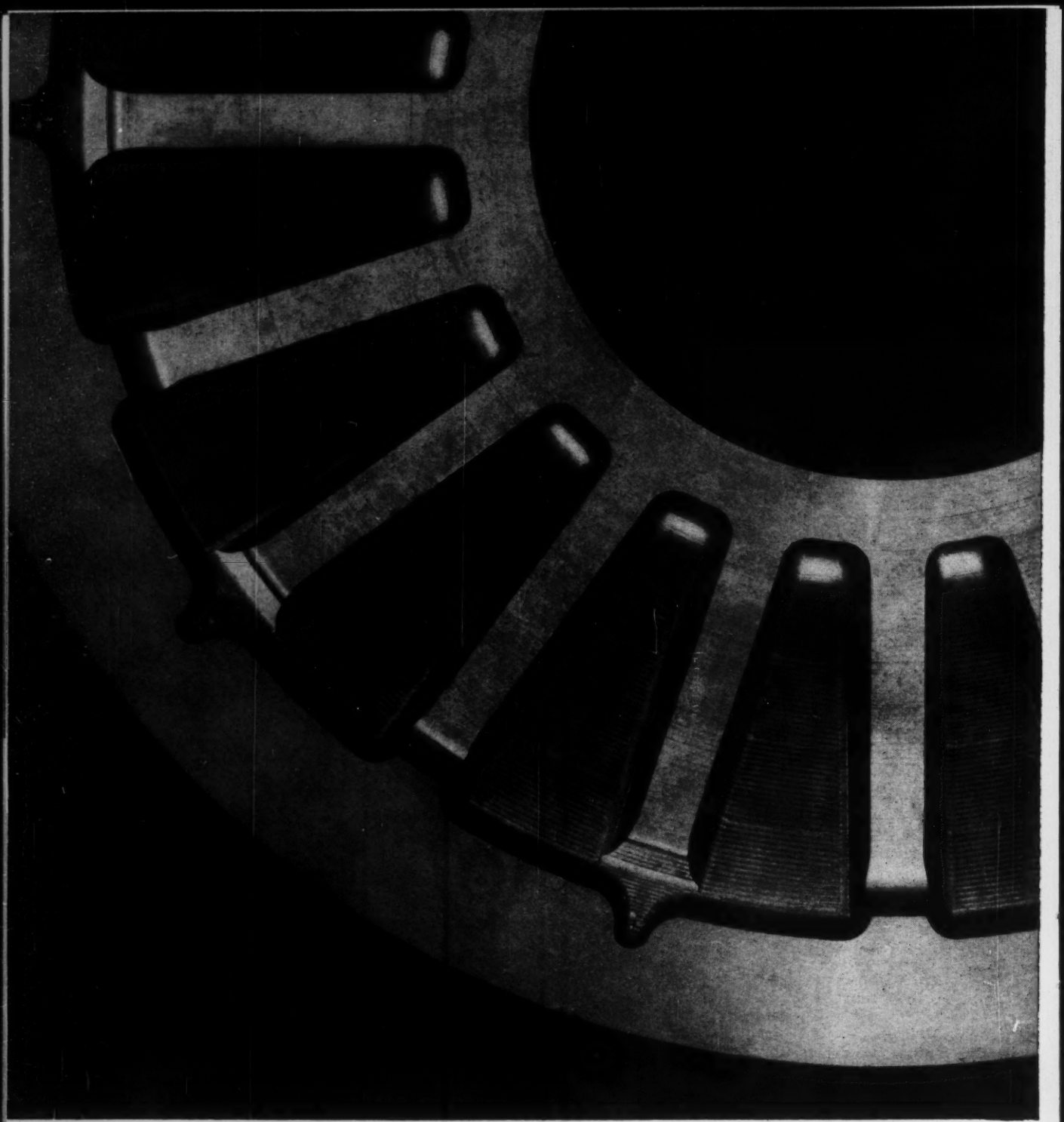
Test frequencies: 120 and 1000 cps
Capacitance range: 0.1 $\mu\mu$fd to 1000 μfd
Capacitance accuracy: .1% of full scale at 25°C
Capacitance resolution: .01% of full scale
Speed of measurement: less than 1 second per parameter
Dissipation factor range: .0001 to .9999 radians
Dissipation factor resolution: .0001 radian of full scale
Dissipation factor accuracy: 0.1% of full scale
Polarizing input: 100 volts maximum
Voltage across unknown: 300 mv to 30 mv
Maximum time to polarize any range full scale: 10 ms

Another significant breakthrough in digital instrumentation from

Electro Instruments, Inc.

8611 BALBOA AVENUE, SAN DIEGO 11, CALIFORNIA

Engineers: *Challenging opportunities now available. Contact Mr. Harvey Fleming.*

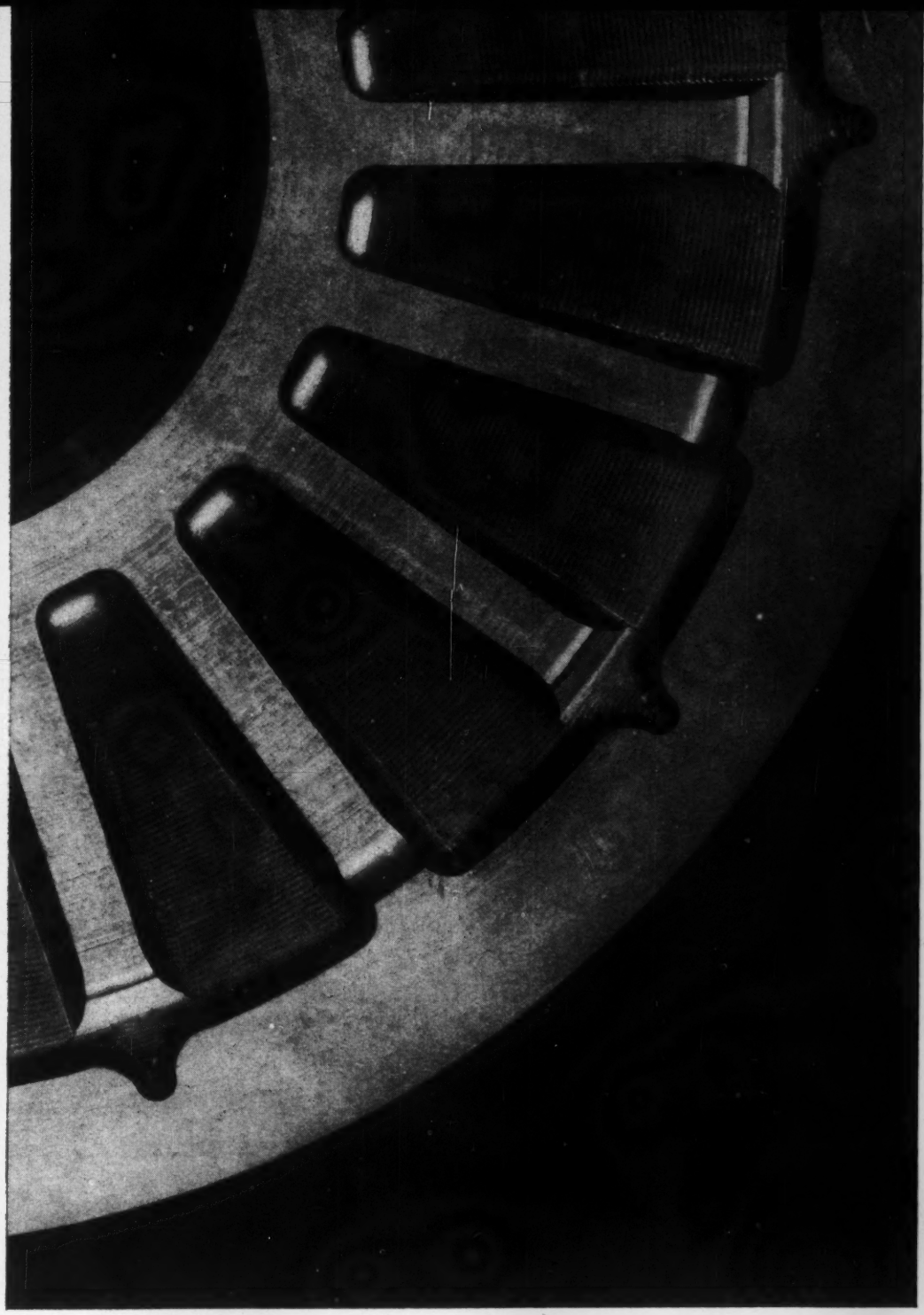


New IBM computer language...AUTOPROMT cuts milling time for this helicopter gearbox cover by 75%

AUTOPROMT (AUTOmatic PROgramming for Machine Tools) is a powerful new computer language designed to broaden the use of numerically-controlled machine tools.

AUTOPROMT, for the first time, lets an engineer *describe the surfaces* of the three-dimensional shape he wants milled, *rather than calculating every path* the tool must follow in order to machine the part.

AUTOPROMT leaves to the computer the task of automatically generating these tool paths. You describe the part to be milled and the tool to be used in simple, *English-like*



terms. The computer does the laborious calculating work.

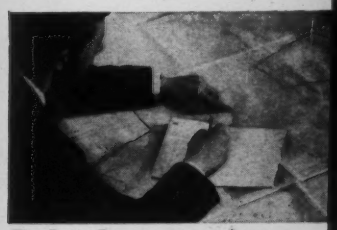
AUTOPROMT produces results like these: the time to mill the gearbox shown in the photographs cut to *one-fourth* the machine time required by conventional methods. AUTOPROMT reduced the lead time from blueprint to production *from three months to two weeks.*

AUTOPROMT is available to IBM customers. Call your local IBM Representative for complete details on this latest advance in Numerical Control of machine tools.

IBM®
DATA PROCESSING

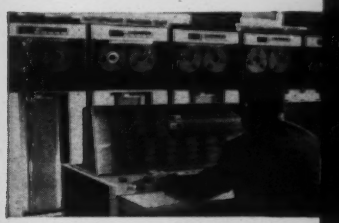
CIRCLE 40 ON READER-SERVICE CARD

Here's the way AUTOPROMT works at United Aircraft Corporation

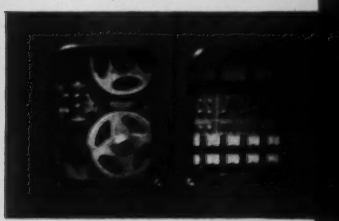


The Parts Programmer, using a conventional blueprint, prepares 180 one-line statements in AUTOPROMT language.

The statements are punched into standard IBM cards and entered into the IBM 7090 Data Processing System. (AUTOPROMT also works with the 704 and 709 Systems).



The 7090, programmed with AUTOPROMT, produces 8000 tool path instructions needed to direct the Pratt and Whitney Co. Inc. Numeric-Keller Continuous Path Milling Machine.



Punched tapes direct the Numeric-Keller Milling Machine.

The Numeric-Keller mills the helicopter gearbox cover.

INCREASE RECORDER VERSATILITY

MULTI-SPEED **CHART DRIVE**

FOR STRIP CHART RECORDERS BUILT BY — HONEYWELL — LEEDS & NORTHRUP — BRISTOL — WHEELCO — GENERAL ELECTRIC (EASILY FIELD MOUNTED)

Matches Chart Speed to Test Requirements • Quick dial selection of eight speeds • Improves resolution and readability of plotted curves • Provides greater total chart speed range • Saves chart paper • Saves valuable time.

CHART DRIVES • SPEED REDUCTORS • INSTRUMENT DRIVE SYSTEMS

INSCO COMPANY

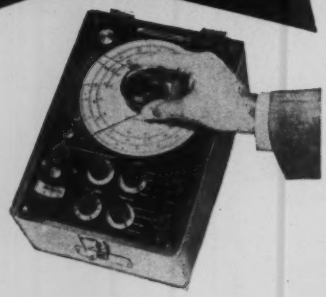
DIVISION OF BARRY WRIGHT CORP.

GROTON, MASSACHUSETTS

CIRCLE 41 ON READER-SERVICE CARD

MODEL 9B PYROTEST

The Most Versatile Portable Potentiometer Made



- Checks any thermocouple-actuated instrument
- Guaranteed accuracy— ⅛ of 1%.
- 9 interchangeable, direct-reading scales

Pyrotest is the only portable potentiometer that can check any thermocouple-actuated indicator, controller, or recorder. It comes with 6 thermocouple scales and 3 MV scales—as easy to change as phonograph records. Scale length of over 4 feet, with high resolution to match. Pyrotest is so accurate, it's used as a standard in the lab . . . so versatile and rugged, it's used as an all-purpose tool everywhere in the plant. Only $315.00, fob Indianapolis. Write for free Bulletin 9-B.

TECHNIQUE **TECHNIQUE ASSOCIATES**

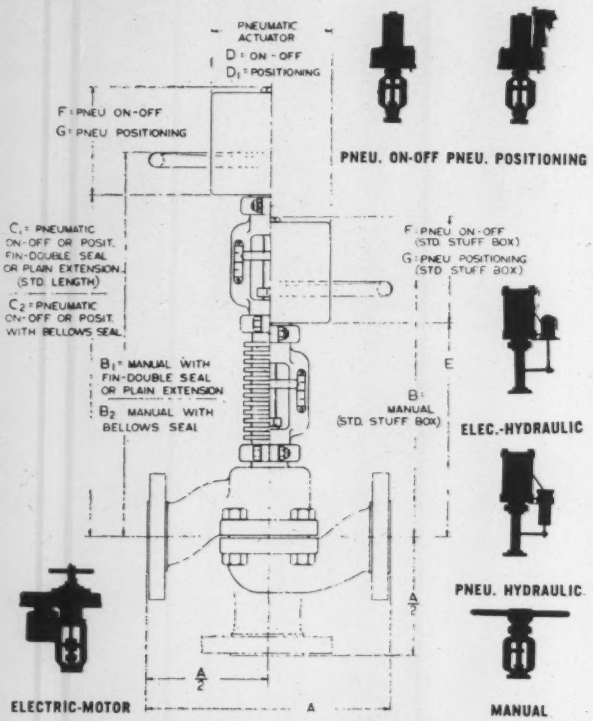
A Division of Duncan Electric Co., Inc.

1413 CORNELL • INDIANAPOLIS 2, INDIANA

CIRCLE 42 ON READER-SERVICE CARD

Split-body Valves

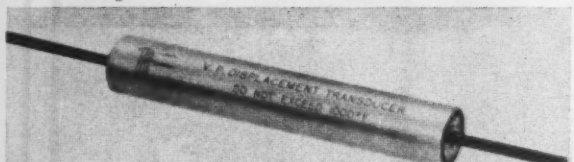
Security Model 020, ASA rated 2500 lb. valve affords versatility, longevity of service, and easy interchangeability in high pressure valve construction, with working


PNEUMATIC ACTUATOR
D = ON - OFF
D1 = POSITIONING
F = PNEU ON-OFF
G = PNEU POSITIONING
PNEU. ON-OFF
PNEU. POSITIONING
C1 = PNEUMATIC ON-OFF OR POSIT. FIN-DOUBLE SEAL OR PLAIN EXTENSION (STD. LENGTH)
C2 = PNEUMATIC ON-OFF OR POSIT. WITH BELLOWS SEAL
B1 = MANUAL WITH FIN-DOUBLE SEAL OR PLAIN EXTENSION
B2 MANUAL WITH BELLOWS SEAL
F = PNEU ON-OFF (STD. STUFF BOX)
G = PNEU POSITIONING (STD. STUFF BOX)
B = MANUAL (STD. STUFF BOX)
ELEC.-HYDRAULIC
PNEU. HYDRAULIC
ELECTRIC-MOTOR
MANUAL

pressure up to 6,000 psig. As in other Security split-body type valves. it is available in globe, angle and 3-way globe or 3-way angle construction. All of the Security actuators including the pneumatic on-off, pneumatic positioning, electro-hydraulic, pneumatic-hydraulic, electric motor driven and manual are easily adaptable to this high-pressure valve series. . . . (*From new 40-page Bulletin 061A, Security Valve Co., 909 El Centro St., South Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 219 ON READER-SERVICE CARD

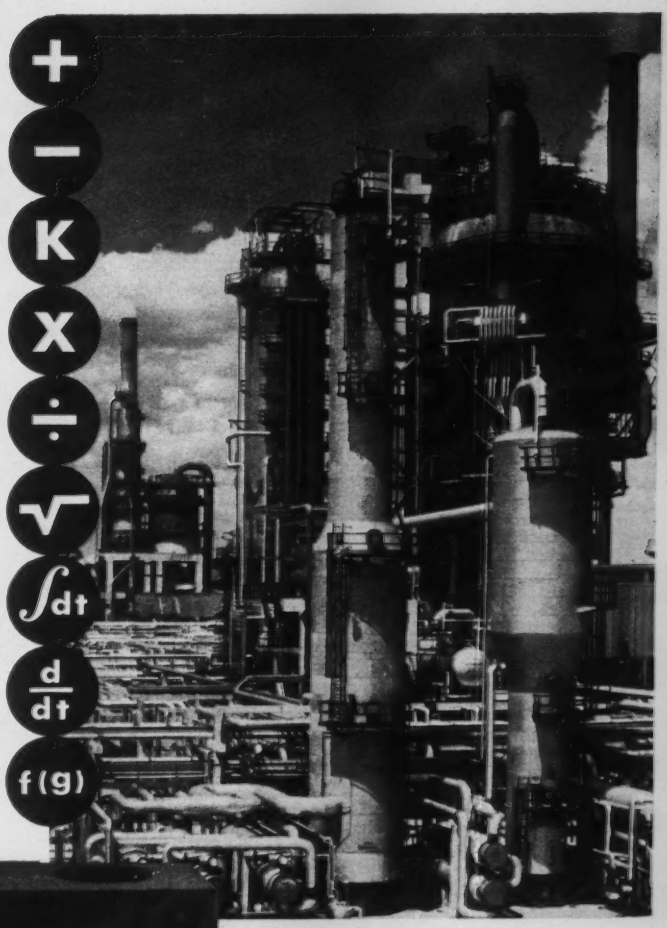
Displacement Transducer

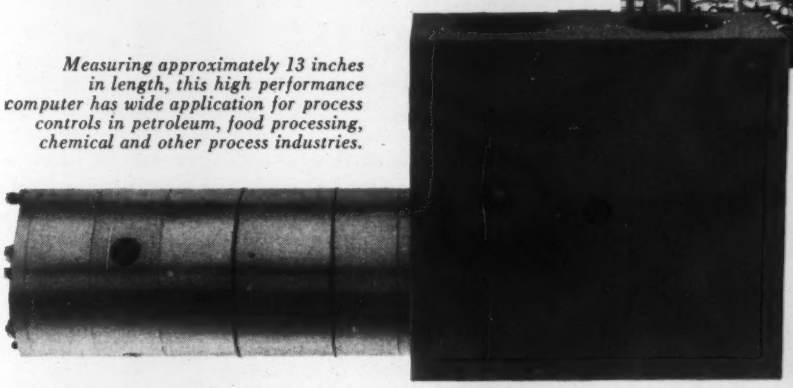


High Temperature variable permeance transducer (has these) specifications: Temperature ranges: —325°F to 1000°F. Circuitry: Variable permeance compensated. Phase change: 180° at null. Sensing slug: T. I. alloy 15 (high temperature compensated chrome-iron alloy) (Curie point 1580°F). Wire: Wound with boron-free Durock insulation aluminum wire. Zero Shift: <.003%/F.S./°F. Thermal Coefficient of Sensitivity: <.003%/F.S./°F. Null Voltage <.25% of total output, etc . . . (*From new 2-page leaflet, Physical Sciences Corp., 389 No. Fair Oaks Ave., Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 220 ON READER-SERVICE CARD

AiResearch introduces pneumatic computer to the process industry





Measuring approximately 13 inches in length, this high performance computer has wide application for process controls in petroleum, food processing, chemical and other process industries.

Provides control accuracy within 1%

- ***Performs all necessary mathematical functions***
- ***Utilizes existing plant instrumentation***
- ***Can receive and transmit electrical signals***
- ***Comparative low costs assure rapid pay-out***
- ***The building block technique of modular construction assures flexibility to cope with problem changes.***

The AiResearch Special-Purpose Pneumatic Analog Computer is the next evolutionary step in process control. It assures continuous on-line solution within one percent overall accuracy of expressions or equations requiring as many as 10 or more mathematical functions.

AiResearch can (a) mechanize your control expressions, (b) assist you in formulating the control expressions and mechanize them, or (c) present you with a packaged system.

This industrial computer system is a result of more than 20 years of experience by AiResearch in the design and manufacture of pneumatic, hydraulic and electronic control systems and components.

• Please direct inquiries to Controls Systems, AiResearch Phoenix Division

THE GARRETT CORPORATION

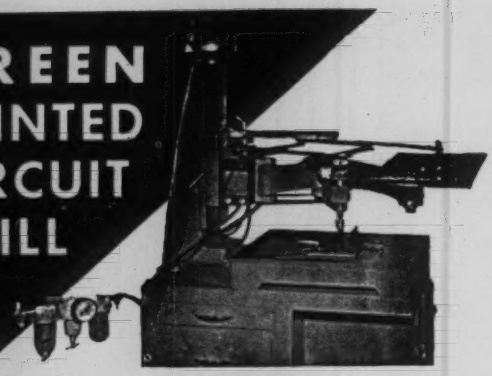
AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

CIRCLE 43 ON READER-SERVICE CARD

GREEN PRINTED CIRCUIT DRILL



A Pneumatic Attachment on The Green Model D2 Pantograph Engraver rapidly drills holes in printed circuits by tracing templates.

- Drill as many as 100 holes per minute. Foot switch actuates air powered operation.
- Drill speeds and feeds have independent adjustments. Feed regulated by air pressure.
- Spindle speeds up to 26,000 rpm. Permits use of carbide drills when required.
- D2-201 air attachment includes spindle air cylinder, regulating valve and pressure gauge, foot switch, filter and oiler, ready to operate when connected to compressor.

The Model D2 Heavy Duty Pantograph Engraver features ratios of 2 to 1 to infinity. Unobstructed on three sides to handle large work. Micrometer adjustment for depth of cut. Vertical range 10" adjusting copy table automatically with pantograph.

GREEN INSTRUMENT CO., INC.

Dept. 83, 295 Vassar St. • Cambridge 39, Mass.

FOR FULL DETAILS, WRITE, WIRE OR CALL

CIRCLE 45 ON READER-SERVICE CARD

Spray on **Statnul**

wipes off static... wipes out error!

Static electricity can cause false readings in panel and test instruments . . . especially with plastic-faced meters. Eliminate this problem for months with new Weston STATNUL. *Spray or apply* with saturated cloth—then wipe. An invisible shield drains away static. *Cleans and polishes* with every application . . . wards off abrasive dust.

Mail coupon today or see your Weston distributor.
Only $3.95! Check or money order enclosed ☐
Bill me. Purchase order enclosed ☐

Name_____

Address_____

City_____ Zone____ State_____

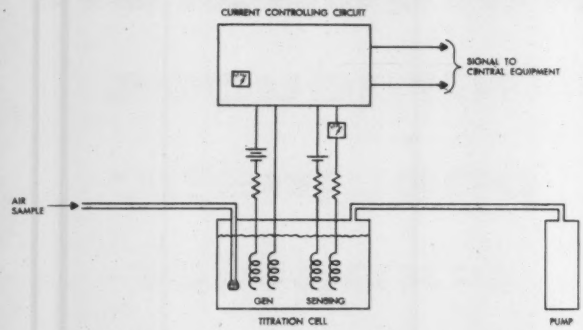
WESTON Statnul a product of DAYSTROM, INCORPORATED

Weston Instruments Division, Dept. IC8, Newark 12, N. J.

CIRCLE 44 ON READER-SERVICE CARD

Gas Sensing Device

A new type of electronic instrument for detecting trace quantities of gases . . . the OLFACTRON . . . aids medical and operating personnel at missile installations, testing sites, and propellant manufacturing plants, by increasing safety in operations involving propellants . . .



In a manner similar to the human being sniffing the air, the OLFACTRON draws air tinged with vapors into its inlet tube, and smells (or analyzes) the presence of particular substances . . . The vapor sniffed by the OLFACTRON's "electronic nostril" is almost instantly converted into an electronic signal which can sound horns, flash lights, turn ventilating systems on or off . . .

In the fuel detector, the fuel vapor is reacted with bromine. The bromine is produced by passing a direct current through a solution of a bromide salt. A pair of platinum electrodes immersed in the solution operate as the generating electrodes . . . A second pair of electrodes, also of platinum, operate to sense the presence of bromine in the solution. This is done by impressing a low voltage on the electrode circuit. Current will not flow unless bromine is present in the solution, and in the presence of free bromine the current is proportional to the bromine concentration. This current-controlling circuit includes a relay which acts as a switch to turn the generating current off at high levels of free bromine, and on at lower levels. This circuit then operates as an automatic control system regulating the bromine supplied to balance the fuel vapor absorbed from the sampled air. This circuit is shown in the functional diagram. The level of electrical current as indicated on a meter or recorder corresponds to the concentration of vapor in the sample . . . (*From* 16-*page Demonstration Report, American Systems, Inc.*, 1625 *E.* 126 *St., Hawthorne, Calif.*)

FOR THIS LITERATURE CIRCLE 221 ON READER-SERVICE CARD

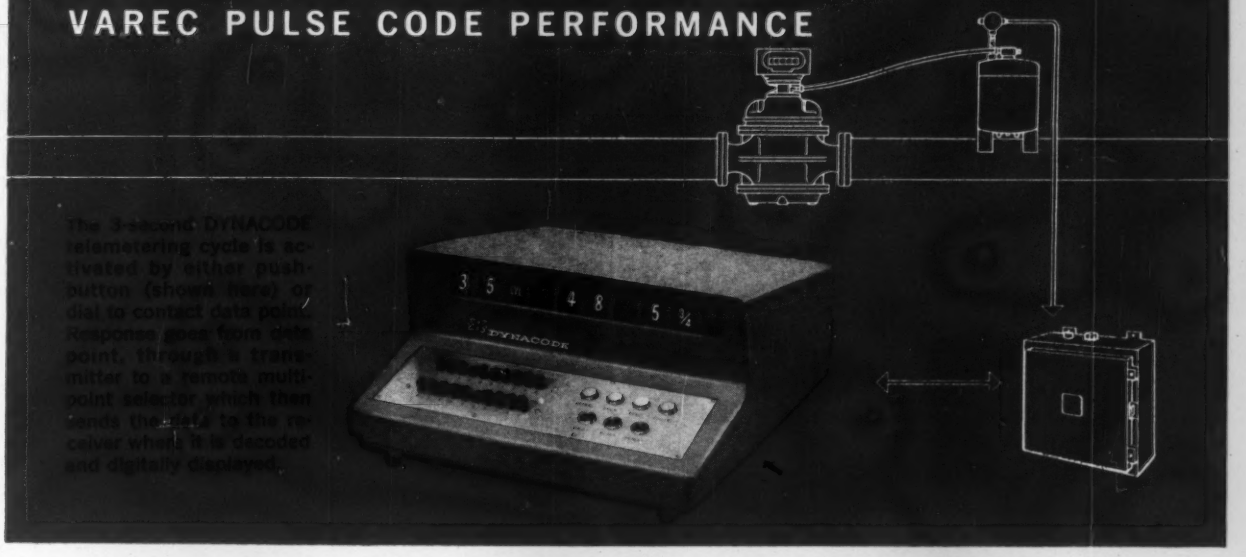
Multi Film Optical Coatings

Multi-Film optical coatings comprise two or more interference films deposited on a surface, usually of glass, quartz, or pyrex, by the well established vacuum evaporation process . . . They afford a simple but highly efficient means of imparting almost any desired reflection or transmission characteristics to an optical surface. On glass plates the various coatings provide color filters, dichroic reflectors, beam dividers and heat control filters, while on first surface mirrors they are used to enhance the reflectance . . . (*From new* 32-*page Catalog E*-306, *Bausch & Lomb Inc., Rochester* 2, *N. Y.*)

FOR THIS LITERATURE CIRCLE 222 ON READER-SERVICE CARD

DYNEL DYNACODE TELEMETERING SYSTEM

A NEW HIGH-SPEED REMOTE MONITORING SYSTEM BASED ON 6 YEARS OF FIELD PROVEN VAREC PULSE CODE PERFORMANCE



The 3-second DYNACODE telemetering cycle is activated by either push-button (shown here) or dial to contact data point. Response goes from data point, through a transmitter to a remote multi-point selector which then sends the data to the receiver where it is decoded and digitally displayed.

Dynel engineers—utilizing the performance proved concepts of Varec's famous Pulse Code system—have developed the significantly advanced DYNACODE telemetering system for remote readings of liquid level, temperature and P.D.M.

This single-channel, "error-proof" system combines the proven reliability of the basic Varec system with a digital readout time of 3 seconds per point... readout accuracy of 1/16 inch... readout capacity of an unlimited number of points... and readout versatility that permits the system to be tied into a general purpose computer for inventory, billing, and similar functions.

Solid state components are used at key points in the receiver design for longer, maintenance-free life. And DYNACODE, like Varec's Pulse Code, has an instantaneous alarm system without scanning delays.

The high-speed DYNACODE System offers these advantages:

Reliability: Design based on 6 years of performance in scores of pipeline and refinery applications.

Data Display: Illuminated, in-line digital display includes point and function identification, digital data to 6 significant figures and liquid level to 1/16" increments.

Fast Response: data from any given point is gathered and digitally displayed in just 3 seconds.

Flexibility: Designed on building block principle that permits a great variety of system arrangements... DYNACODE is compatible with all standard systems of measurement.

Readout Variety: digital output provides a variety of readouts, including visual display, paper tape, typewriter, etc. Output is compatible for use with general purpose computers.

For complete information, see DYNACODE at the ISA Show, Los Angeles Sports Arena – Booth #170. Or write for Bulletin 301, Dept. ICS-1600-1

DYNEL, Inc., *a subsidiary of Varec, Inc.*

12923 S. Spring Street, Los Angeles 61, California • Branches and Representatives in Principal Cities

CIRCLE 46 ON READER-SERVICE CARD

..HIGH VOLTAGE TESTING
of CABLES, MOTORS, GENERATORS
and All Electrical Equipment

Mobile D-C HYPOT®

Rugged . . Mobile . . for Production, Installation and Maintenance Testing

Output . . 120 kv models provide up to 5000 microamperes d-c., 75 and 45 kv models to 10 ma, 4-c.

115v A-C Line . . Input through three-conductor power cord with two prong plug and grounding clip.

Self-Contained, Fully Portable . . Single mobile housing with rubber tired wheels and push handle contains metering circuitry and high voltage supply.

Safe, Simple Operation . . Direct reading of insulation leakage current. Fully interlocked, cabinet grounded, output cable shielded.

Measures
Dielectric Strength
Insulation Resistance
Dielectric Absorption

Write for Manual J-67
"Methods for Insulation Testing . . Engineering . . Production . . Maintenance

4-35.8

ASSOCIATED RESEARCH, Incorporated
"Electrical Testing Instruments Since 1936"

3766 W. Belmont Ave., Chicago 18, Illinois
CIRCLE 47 ON READER-SERVICE CARD

OPTICS

A. D. JONES OPTICAL WORKS

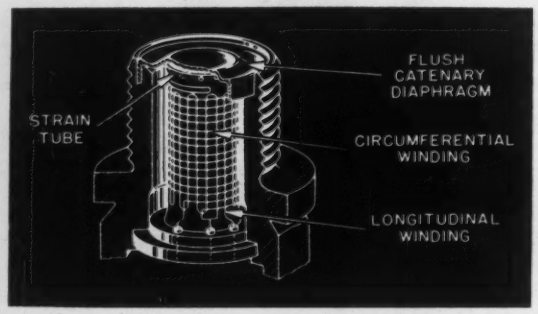
2400 MASSACHUSETTS AVENUE
CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368—3369

People usually associate Optics with glass only. The following materials, successfully processed here by sawing, grinding and polishing or drilling are of value to designers, engineers and manufacturers. Most materials are supplied by our customers for their orders.

ALUMINA
ALUMINUM
ARSENIC TRISULPHIDE
BARIUM TITANATE
BRASS
CALCIUM TUNGSTATE
CARBORUNDUM
CERAMIC
COBALT FERRITE
COPPER
CORNING 707
CORNING 7052
FERRITE
FERROX
FLUORIDE, CALCIUM
FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNESIUM STANIDE
NICKEL OXIDE
NIOBIUM
PLATINUM
POTASSIUM BROMIDE
PYREX
QUARTZ, CRYSTAL
QUARTZ, FUSED
SAPPHIRE
SILICON
SODIUM CHLORIDE
STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
VYCOR
X-RAY LEAD GLASS
VANADIUM

CIRCLE 48 ON READER-SERVICE CARD

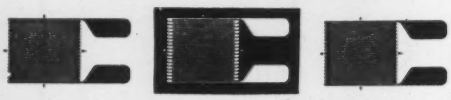
Strain Gage Pressure Transducer



The Norwood bonded strain gage pressure transducer is a device for precision measurement of static and dynamic pressures. The transducer incorporates a pressure-sensitive diaphragm and a strain tube with bonded strain gages. The small mass and minute deflection of this assembly result in exceedingly high frequency response characteristics. The assembly is virtually unaffected by extreme vibration or acceleration . . . The pressure to be measured is imposed upon the diaphragm. As the pressure increases, the slender cylindrical tube decreases in length while increasing in diameter. These dimensional changes are instantly detected by the strain gages which are bonded directly onto the strain tube in such a manner that the resistance of the circumferential winding increases and the resistance of the longtitudinal winding decreases. The unbalance in resistance is proportional to the applied pressure. Standard Norwood Transducers provide a complete range of models for measurement of pressures up to 60,000 psi . . . (*From 6-page Bulletin 278, American-Standard Controls Div., 5900 Trumbull Ave., Detroit 8, Mich.*)

FOR THIS LITERATURE CIRCLE 223 ON READER-SERVICE CARD

Foil Strain Gages

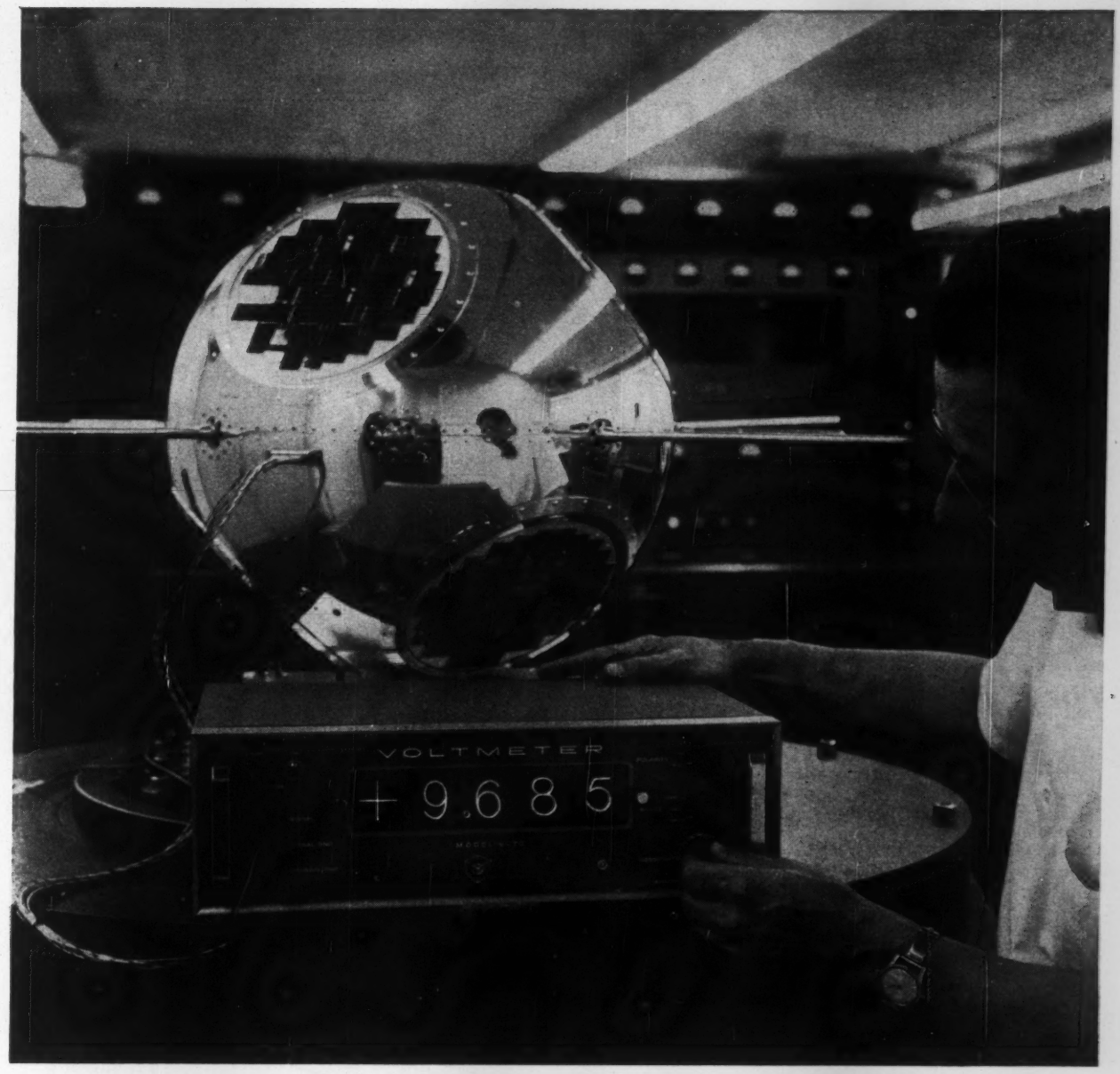


Recently, bonded resistance strain gages have been advanced considerably in performance through the replacement of wire by thin metal foil etched into the desired grid shape . . . Some of the more important advantages of the foil gage are as follows: (1) Exact reproduction of physical dimensions from gage to gage of the same type, ensuring consistent performance. (2) Higher fatigue life because of the elimination of internal joints and stress concentrations. (3) Greatly increased bonding area for each grid strand due to the large width of the foil conductor when compared to its thickness . . . (4) Reduced transverse sensitivity afforded through large area end-loops . . . (5) Increased flexibility, ruggedness and conformability through decreased gage thickness, etc . . .

Series EA and EP (are) general purpose types for static and dynamic measurement to approximately +200°F. . . (*From new 8-page Catalog EA-1, Allegany Instrument Co., Div. Textron Electronics, Inc., Cumberland, Md.*)

FOR THIS LITERATURE CIRCLE 224 ON READER-SERVICE CARD

(*Continued on page* 1390)



NEW DVM CONCEPT!

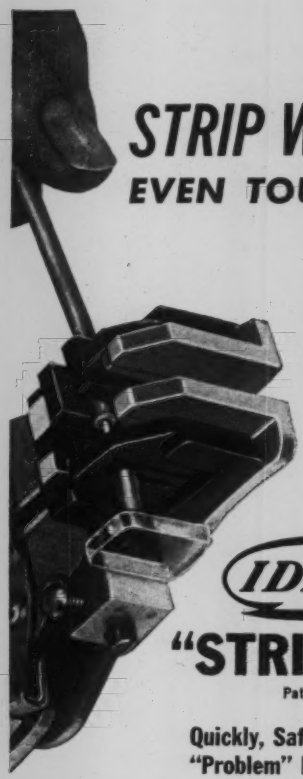
FAST: *Two readings per second* ***ACCURATE:*** *0.01% accuracy* ***LOW COST:*** *Only $1,580*

In the above test of a satellite's telemetry and solar cells, it was necessary to make 100 accurate measurements every minute. The job was done with the new Cubic V-70 digital voltmeter that reads out four times as fast as any instrument with stepping switches. The V-70 uses ultra-reliable reed relays hermetically sealed in glass for a life expectancy of at least 10 years. It has no moving parts, requires no maintenance, will operate in any position, and is resistant to thermal and physical shock. The V-70 is the only DVM offering 0.01% accuracy and less than 1 second balance time for less than $2,000 (Model V-70, $1,580; Model V-71 with automatic ranging and polarity, $2,200). For details, write to Dept. IC-107.

cubic
CORPORATION
INDUSTRIAL DIVISION
SAN DIEGO 11, CALIFORNIA

OTHER OFFICES: LOS ANGELES, CALIFORNIA • ROME, ITALY (CUBIC EUROPA S.p.A.) • REPRESENTATIVES IN PRINCIPAL U.S. AND CANADIAN CITIES

CIRCLE 49 ON READER-SERVICE CARD



STRIP WIRE FAST--
EVEN TOUGH TEFLON*
WITHOUT A NICK!

IDEAL CUSTOM
"STRIPMASTER"
Patented, No. 2,523,936

Quickly, Safely Removes "Problem" Insulation from Wire

Now strip the toughest insulation from any wire with just a gentle, harmless squeeze. With Ideal Custom Stripmaster, matched sets of counterbored blades—*precision drilled on watchmaker's equipment to fit wire sizes exactly* are designed to ride on cut insulation, and eliminate wire nicking and scraping. Firm grip of jaws prevents insulation damage. Wire is stripped absolutely clean up to a full ⅞".

Optional transparent wire stop quickly adjusts so that you strip off the exact amount of insulation you want every time. Perfect for fast, accurate production line stripping.

Custom Stripmasters come in three models for 10 to 14, 16 to 26, or 26 to 30 wire gauges.

SOLD THROUGH AMERICA'S LEADING DISTRIBUTORS

In Canada: Irving Smith, Ltd., Montreal

*Reg. Trade Mark of DUPONT

The Custom Stripmaster is just one of a complete line of Ideal strippers including Thermo-Strip and high-speed electrically powered models for every insulation-removal need. WRITE FOR NEW WIRE STRIPPER BROCHURE.

IDEAL INDUSTRIES, Inc.
1420-H Park Ave., Sycamore, Ill.

Please send me a copy of your new WIRE STRIPPER BROCHURE

Name_____

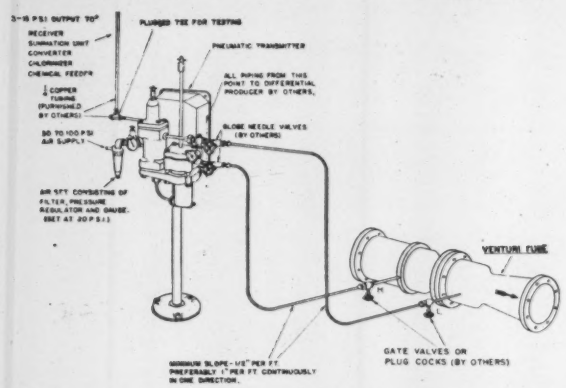
Company_____

Address_____

City_____ Zone_____ State_____

CIRCLE 50 ON READER-SERVICE CARD

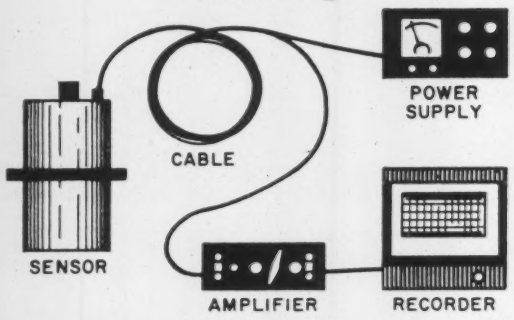
Pneumatic Flow Transmitter


PNEUMATIC TRANSMITTER
ALL PIPING FROM THIS POINT TO DIFFERENTIAL PRODUCER BY OTHERS.
GLOBE NEEDLE VALVES (BY OTHERS)
VENTURI TUBE
GATE VALVES OR PLUG COCKS (BY OTHERS)

Pneumatic Flow Transmitter, mercury operated Model 281-01, is an instrument designed to produce an output air pressure proportional to the rate of flow through a differential producer. It is normally used in conjunction with such Differential Producers as Venturi Tubes, Dall Flow Tubes, Venturi Nozzles, Orifice Plates, or, as in the case of loss of head, the pressure differential created across the equipment used. The differential pressures are transmitted through piping to the surfaces of mercury in the two wells of the Flow Transmitter. A float in the low-pressure well is actuated and pressure changes are transmitted via chain, chain spool and operating shaft to the cam. The cam is custom calibrated, using water test heads over the entire range specified . . . (*From new* 4-*page Spec Sheet* 281-01201-1, *B-I-F Industries, Providence, R. I.*)

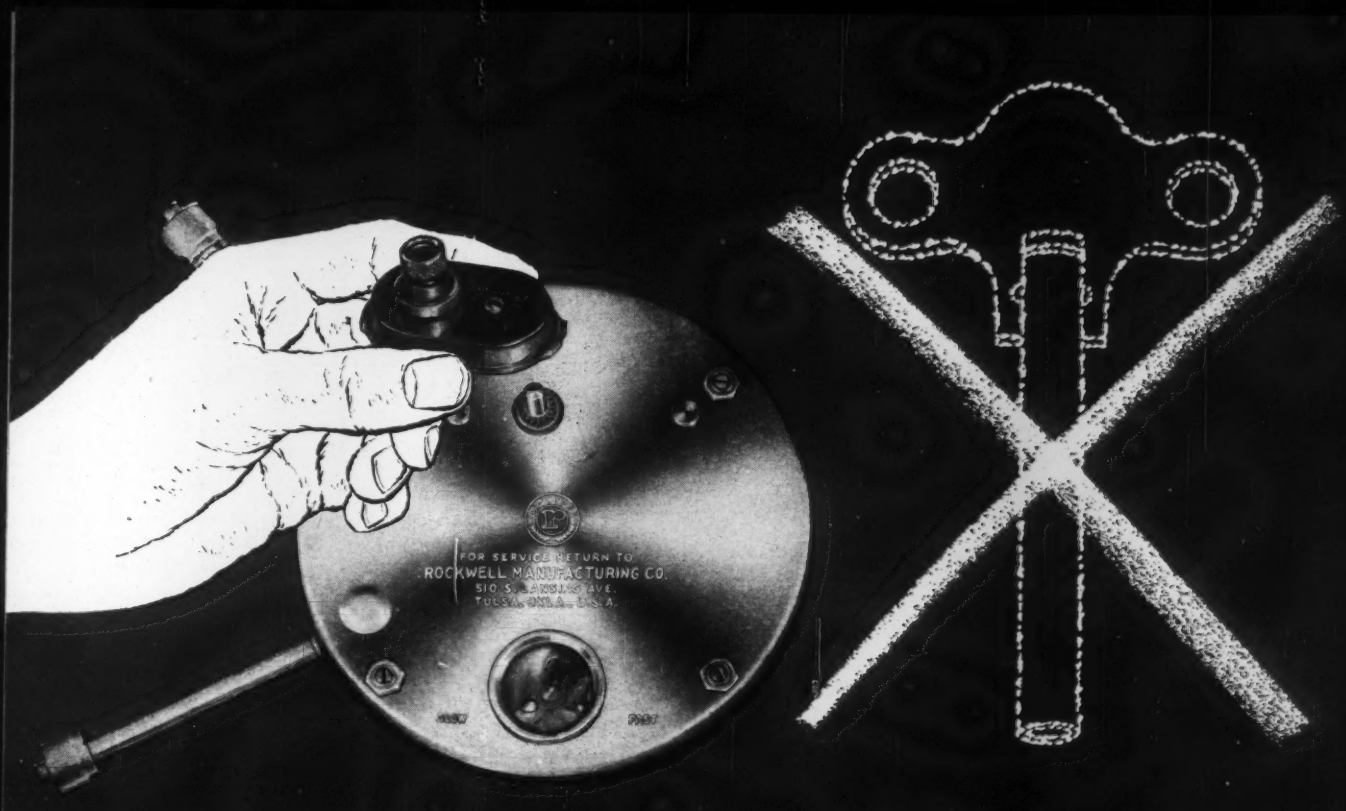
FOR THIS LITERATURE CIRCLE 225 ON READER-SERVICE CARD

Long-wave (Pressure) Recording



In the Frank Snodgrass Mark III unit . . . very fast pressure changes (i.e., sea-swell) are greatly attenuated in passing through hydraulic filters to the strain-gage type differential pressure transducer, with the result that such changes produce no differential pressure to actuate the transducer. On the other hand, very slow pressure changes (i.e., tides) are negligibly affected by the filters, and again no differential pressure exists to actuate the transducer . . . A complete system usually consists of the pressure sensor installed in the ocean, a 4-conductor connecting cable running to shore, a bridge power supply, an amplifier, . . . and a chart recorder . . . (*From new* 2-*page Bulletin "Model A-la," Marine Advisers, Box* 1963, *La Jolla, Calif.*)

FOR THIS LITERATURE CIRCLE 226 ON READER-SERVICE CARD



Illustrating how speed changing turrets are applied to the chart arbor

You never need to wind the Rockwell Gas Drive

GAS (OR AIR) POWERS THIS NEW CHART TIMING DRIVE. With it you can forget the costly chore of periodic winding. It's completely self-starting, self-contained. You can use the Rockwell Gas Drive with profit and gain accurate, automatic operation of recording charts on practically any make orifice meter, gas lift intermitter, pressure recorder or temperature gauge. It is particularly applicable for remotely located instruments.

Since the Rockwell Gas Drive consumes only 6 cubic feet of gas in 24 hours it is economical to use—safe, too, for there is no exhaust problem.

The Gas Drive operates on a pressure range of 15-25 psi and delivers 15 in. lbs. of torque to the main arbor which rotates once every 24 hours. Geared turrets which snap onto this arbor provide optional speeds of 2, 3, 4, 6, 12, 48 or 72 hour, 7 or 8 day rotation. So with a stock of Rockwell Gas Drives, plus a selection of economical turrets, you can serve all your instrument needs. Get facts now. Write Rockwell Manufacturing Company, Pittsburgh 8, Pa. In Canada: Rockwell Manufacturing Company of Canada, Ltd., Guelph, Ontario.

◀ Rockwell Gas Drive powers this typical intermitter

GAS DRIVES, CHART DRIVES

another fine product by

ROCKWELL

CIRCLE 33 ON READER-SERVICE CARD

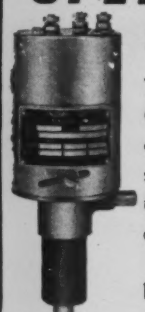
CRUCIBLE'S HANDBOOK CAN HELP AVOID MISTAKES IN PERMANENT MAGNET DESIGN. Now design errors can be eliminated from permanent magnet gap dimensions, sizes, alloys, etc. Refer to this 346-page Crucible *Permanent Magnet Handbook*. It's the most complete reference of its kind! It gives all the data you need to design permanent magnets into generators, meters, compasses, hi-fi and TV systems, etc. It also discusses ferromagnetism, electromagnetic theory, and over 60 different magnet materials, For your copy of this *Permanent Magnet Handbook*, send check or money order for $10* to *Crucible Steel Company of America, Four Gateway Center, P.O. Box 88, Pittsburgh 30, Pa.*

**Add 40¢ for state sales tax if you are located in Pennsylvania.*

CRUCIBLE STEEL COMPANY OF AMERICA

CIRCLE 52 ON READER-SERVICE CARD

TWO ELEMENT *SPEED SENSITIVE* SWITCHES



The Synchro-Start Models GH-2 and GS-2 governors contain two snap action switches to be used for opening or closing circuits at any RPM over 300

They contain sealed ball bearings, are adjustable while running and are encased in a splash proof housing. These two switch governors are supplied for the standard SAE tachometer drive or distributor take-off and for AND20005 engine pad mounting (GA Series).

Other Synchro-Start governors are available with one and three switches with a variation of mountings.

SYNCHRO-START PRODUCTS, INC.

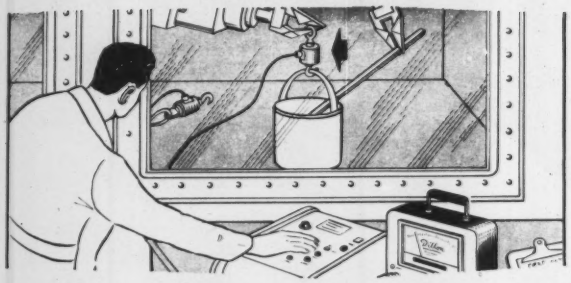
8151 NORTH RIDGEWAY AVENUE, SKOKIE, ILLINOIS

Manufacturers of

AUTOMATIC ENGINE CONTROLS • SPECIAL CONTROL PANELS
SAFETY ALARM SETS • D.C. SOLENOIDS • HEAVY DUTY RELAYS

CIRCLE 53 ON READER-SERVICE CARD

Load Cell System

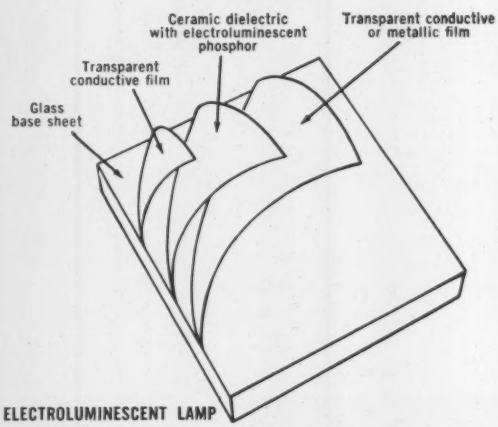


Load Cell consists of an alloy steel case, with threaded stud at one end and internal threads at opposite end. Wide choice of fittings permits operator to work in tension, compression or push-pull. Construction embodies two transformers, each with its own primary and low impedance secondary, enclosed in ceramic iron cup cores. Spaced between these is a ferrous gap disc, the shaft of which is mounted to one end of Load Cell case.

In operation, the case elongates or compresses thereby displacing position of the disc in relation to transformers. This movement produces an electrical output exactly proportional to the displacement. Total displacement for full scale reading varies between .002″ and .005″ depending upon capacity . . . Measurement of force in remote locations or in situations where the element of danger makes it unwise for an operator to get too close, are problems easily solved . . . Weighing radio-active materials is made safe with Dillon remote reading Load Cell System . . . (*From new* 12-*page Bulletin R-2, W. C. Dillon & Co., Inc.,* 14620 *Keswick St., Van Nuys, Calif.*)

FOR THIS LITERATURE CIRCLE 227 ON READER-SERVICE CARD

Electroluminescent Panels


Ceramic dielectric with electroluminescent phosphor
Transparent conductive or metallic film
Transparent conductive film
Glass base sheet

ELECTROLUMINESCENT LAMP

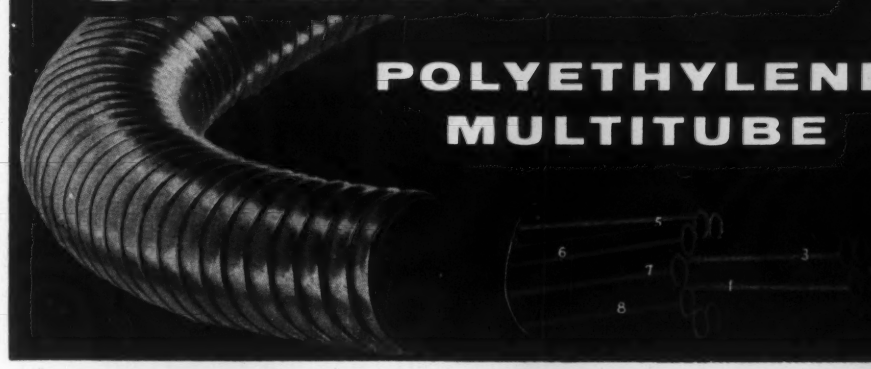
Sylvania readouts . . . are made up of segments of electroluminescent lamps, insulated from each other and separately terminated. When segments are excited, they produce symbols for visual display. Sylvania numeric and alpha-numeric panels, either singly or in groups, can be used to form numbers, letters of the alphabet, various foreign language characters, plus and minus signs and punctuation . . . (*From new* 4-*page Brochure ET*-3995, *Sylvania, Subs. of General Telephone & Electronics, Electronic Tube Div.,* 1740 *Broadway, New York* 19, *N. Y.*)

FOR THIS LITERATURE CIRCLE 228 ON READER-SERVICE CARD

CRESCENT

POLYETHYLENE MULTITUBE

VALUE



with INDIVIDUALLY NUMBERED TUBES

INDIVIDUALLY NUMBERED TUBES—Numbers in white appear at 2-1/2" intervals throughout the length, thus permitting positive identification of every tube anywhere along the length, as well as at each end.

BLACK POLYETHYLENE TUBES—Pigmented, high molecular weight virgin polyethylene Type P tubes are employed for maximum resistance to environmental stress cracking and aging in sunlight.

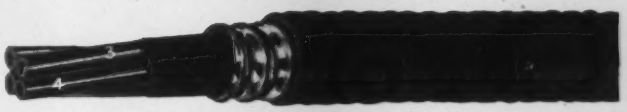
THREE STANDARD TYPES TO MEET YOUR SPECIFIC NEED

CRESCENT POLYETHYLENE MULTITUBE is composed of 2 to 37 individually numbered black Type P Tubes, cabled together under a heavy, waterproof PVC tape with a flexible, interlocked, galvanized steel armor for complete mechanized protection. A polyvinyl chloride (PVC) sheath can be furnished over the steel armor for permanent protection from the weather and any corrosive exposure.

STANDARD TYPES

TYPE PA—Interlocked metallic armor provides complete mechanical protection to the inherently corrosion resistant tubing.

TYPE PAT—Polyvinyl chloride sheath over the armor adds corrosion protection for the armor. Can be buried in the earth.



TYPE PT—PVC sheath gives limited mechanical protection. For use in troughs, trays or conduit.

CRESCENT POLYETHYLENE PRECISION INSTRUMENT TUBING—TYPE P developed through extensive research, improved manufacturing methods and rigid test standards, will continue to be available in 1/4", 3/8" and 1/2" OD sizes in up to seven bright colors and black for use as single tubing behind panels and in MULTITUBE when specified.

WRITE FOR BULLETIN NO. 960-A

CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON, NEW JERSEY

CIRCLE 54 ON READER-SERVICE CARD

WORLD'S MOST ACCURATE AIR PRESSURE REGULATOR

• MAINTAINS PRESSURE TO 1/5 OF 1/10 OF 1% OVER RANGE OF SUPPLY PRESSURE, FLOW, AMBIENT TEMPERATURES.

The exclusive use of *regulated air pressure* instead of supply pressure is the secret of unmatched performance.
Constant reliability results from stainless steel pressure capsule which assures stable movement under all ambient temperatures.
Three pressure ranges: 2-25; 3-60; 3-125 and NPT pipe sizes ⅛", ¼" and ⅜". Write for bulletin or send purchase order.
Unconditionally guaranteed to perform in accordance with above curve for Lexington Regulator type 10. *(Protected by U.S. and foreign patents)*
Price: $20.00 plus postage with quantity discounts.

Lexington Controls
INCORPORATED
63 Blanchard Road, Burlington, Mass.

CIRCLE 55 ON READER-SERVICE CARD

DRAKE "ECONOGLO" Neon Glow INDICATOR LIGHT ASSEMBLIES *for maximum performance at minimum cost . . .*

Ideal as low-budget indicators on standard line voltage. Thoroughly practical—easy to mount from front of panel, secured by Tinnerman nuts or Snap-in plugs. Available with or without current-limiting resistors...with either plain or fluted lenses, or flat caps—plain or numbered...in your choice of Colorless, Red, Yellow, White. High-brightness neon glow lamps give clear visibility, long life.

"Econoglo" units are suggested for such applications as: *Radio and TV, Hi Fi, Communications Equipment, Computers, Instruments, Toys, etc., etc.*

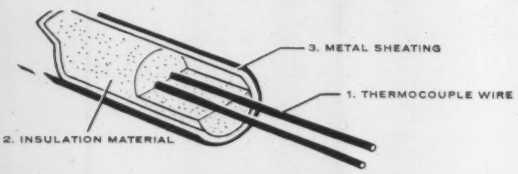
★ SEND FOR DATA FOLDER 6107 AND SEE US AT BOOTH 318 WESCON SHOW

DRAKE
MANUFACTURING COMPANY
4624 N. OLCOTT AVENUE • CHICAGO 31, ILLINOIS

MINIATURE LIGHTING SPECIALISTS

CIRCLE 56 ON READER-SERVICE CARD

Ceramic Insulated Thermocouples

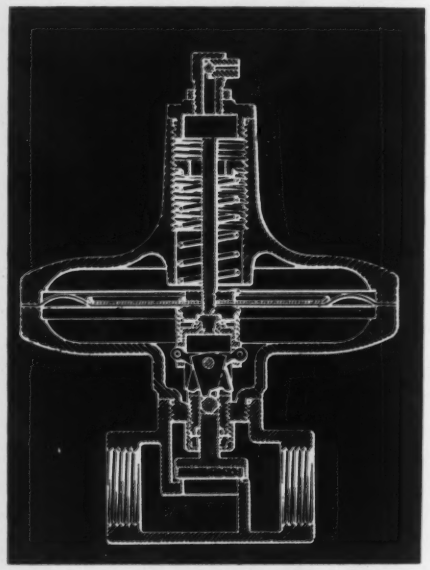


Mineral oxide insulated sheathed thermocouples to precise critical characteristics are custom designed and produced for the special applications involved . . . Tempak precision ceramic insulated thermocouple material . . . is not affected by conditions of extreme vibration, moisture and shock . . . Thermocouple wires are individually tested against Platinum 27 Standards . . . Insulation in the form of Magnesium Oxide (MgO) or other crushable mineral insulation preforms, after vacuum drying followed by a cycle of inert gas back-filling, are carefully threaded on the wires . . . Metal sheath tubing, chemically cleaned to surgical standards, is slipped over the wire and insulator assembly . . . Tempak with chromel alumel wires is aged in a vacuum furnace on a pre-selected time-temperature program to restore and stabilize the calibration . . . (*From new* 12-*page Catalog* 2550, *Temptron, Inc.*, 7030 *Darby Ave., Reseda, Calif.*)

FOR THIS LITERATURE CIRCLE 229 ON READER-SERVICE CARD

Gas Safety Regulators

The Gasco Automatic Safety Gas Pressure Regulator automatically shuts off the gas should the inlet pressure fail or drop below an established safe limit . . . in the



event of diaphragm failure due to fire . . . in case of excessive back pressure . . . when its ambient temperature is raised to 125 degree F . . . remains closed and must be manually reset when the inlet pressure has been safely restored . . . (*From new* 6-*page Special Report, Gas Appliance Specialties Co.*, 32-37 *Fifty-sixth St., Woodside, L. I., N. Y.*)

FOR THIS LITERATURE CIRCLE 230 ON READER-SERVICE CARD

DORSETT'S 3 NEW SILICON SOLID STATE SUBCARRIER OSCILLATORS FOR FM TELEMETRY

To meet increased demand for a wide range of subcarrier oscillator configurations Dorsett Electronics now offers its extremely reliable solid state subcarrier oscillator in three new package forms.

Dorsett's three new configurations provide the systems engineers with unmatched mechanical flexibility in telemetry system design, without sacrificing component reliability and stability.

These new subcarrier oscillators are only a few of the many state of the art telemetry components currently in production at Dorsett Electronics. Put Dorsett's experience to work for you on your next telemetry requirement. Your inquiries and specifications will receive a prompt reply.

SPECIFICATIONS

Input:	0 to 5 volts, or −2.5 volts to +2.5 volts.
Output:	Adjustable from 0 to .5 volts RMS into 8K load impedance. Fixed output at least 3 volts RMS into 100K or higher load impedance.
Power Requirements:	28 volts DC at 10 milliamperes.
Linearity:	Deviation from the best straight line less than .25%.
Distortion:	Less than .75% harmonic distortion.
Amplitude Modulation:	Less than 1db across the band.
Input Impedance:	500K for Channels 1 through 18. 250K for Channels A through E.
Electrical Stability:	No more than ±.5% FBW change in center frequency or deviation sensitivity for a supply voltage change of ±10%.
Temperature Stability:	Less than 2% FBW change in center frequency or band-width for a 50°C change within the range of −55°C to +100°C.
Acceleration:	100G Linear
Vibration:	20G, 55 to 100 cps
Shock:	100G for 11 milliseconds
Altitude:	Unlimited
Size:	**0-18** 1.75 in. x 1.36 in. x .76 in. **0-20** 2.25 in. x 1.88 in. x .88 in. **0-28** 1.27 in. x 1.25 in. x 1.25 in.
Connector:	Cannon DE-9P.
Controls:	Output, Centering, Deviation Sensitivity

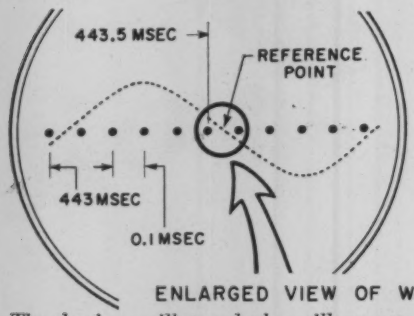
DORSETT ELECTRONICS, INC.

P. O. BOX 862 • NORMAN, OKLAHOMA • JEFFERSON 4-3750

CIRCLE 57 ON READER-SERVICE CARD

Frequency and Time Standards

Frequency and time standard systems are used for frequency and time control or calibration at manufacturing plants, physical research laboratories, . . . missile and satellite tracking stations . . . High-accuracy master standards of frequency and time are provided in convenient broadcasts from radio stations such as WWV . . .



ENLARGED VIEW OF WAVEFORM

The basic oscillator-clock-oscilloscope system uses the tick output of the clock to trigger the oscilloscope sweep. By observing the WWV tick while adjusting the phasing of the clock tick output, both ticks can be brought into time coincidence or near-coincidence. The calibrated tick phasing control (reading accuracy better than 10 microseconds for the Model 113AR/BR) then gives the desired clock time reference . . .

Systems which include the Model 114AR/BR Time Comparator permit clock tick output to remain on-time during the time-comparison measurement . . . The measurement procedure is similar to the basic procedure . . . but is simplified by comparator-generated time marks supplied to the oscilloscope . . . (*From new 56-page Application Note 52. Write on company letterhead to Harry J. Lewenstein, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.*)

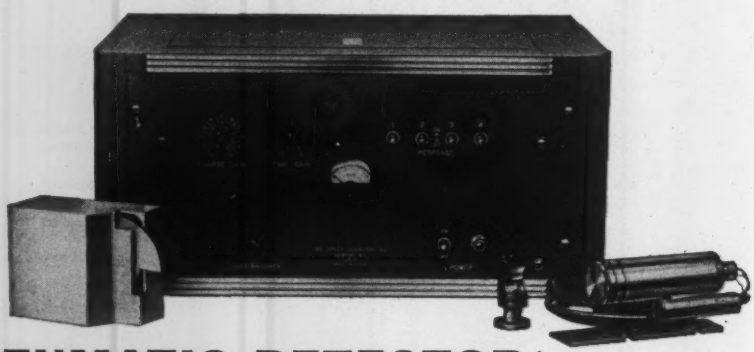
FOR THIS LITERATURE CIRCLE 204 ON READER-SERVICE CARD

Angular Position Transducer

The B-L-H Angular Position Transducer, Model 236, is a device designed to continuously and accurately measure limited angular displacements. An output millivoltage is developed whose magnitude varies linearly with the angular position of the transducer shaft . . . The transducer input shaft is fastened to a special steel beam onto which four (4) SR-4® Strain Gages are bonded. The strain gages are wired into a four-arm Wheatstone Bridge whose resistance unbalance is a function of input shaft rotation. This change is indicated as a millivolt output signal which can operate various types of readout equipment . . . (*From new Product Data 4353, Baldwin-Lima-Hamilton, Electronics & Instrumentation Div., Waltham 54, Mass.*)

FOR THIS LITERATURE CIRCLE 231 ON READER-SERVICE CARD

A Superior Detector for Infra-Red Spectroscopy



GOLAY PNEUMATIC DETECTOR*

Among the characteristics that render the Golay Detector superior to other types of detectors for use in infra-red spectroscopy are:

1. **An effective sensitive area 3/32" in diameter.**
2. **Sensitivity of 6 x 10^{-11} watts RMS-ENI when used with "chopped beam" method and with recording time constant of 1.6 second.**
3. **Uniform sensitivity from the ultra-violet through the visible and the entire infra-red, and up to the microwave region.**
4. **Improved, drift-free. A. C. operated amplifier with step gain controls and four response periods.**

Write for EPLAB Bulletin No. 10

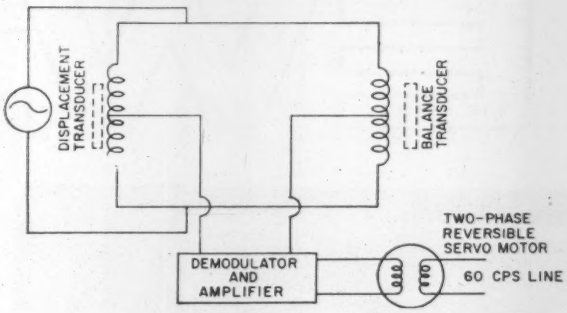
*Fundamental and experimental aspects of this detector are discussed in the following publications: Rev. Sci. Inst. *18*, 347 and 357 ('47); ibid. *20*, 816 ('49); Proc. IRE *40*, 1161 ('52).

278-8

THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
2 Sheffield Ave. • Newport • Rhode Island • U.S.A.

CIRCLE 58 ON READER-SERVICE CARD

Digital Electromicrometer

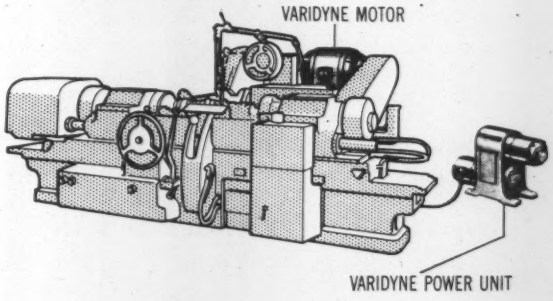


For digital readout in micro inch displacement of variable permeanace transducers, particularly suited to PSC Type Series TI-A Transducers . . .

A variable permeance transducer consisting of two matched impedances forming half of an inductive bridge is located at the point of desired measurement. The inductive balance is varied by means of the translation of a chromium-iron slug (probe) attached to the test specimen. The internal bridge balance consists of an identical variable permeance transducer which is driven to a null position by means of a closed loop servo system. The mechanical system which drives the balance slug is coupled to a digital indicator . . . (*From new 2-page Bulletin EM-2, Physical Science Corp., 389 N. Fair Oaks Ave.*, Pasadena, Calif.)

CIRCLE 280 ON READER-SERVICE CARD

Speed Control Systems

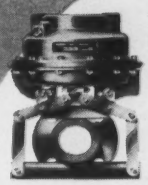


Grinder Control utilizing Varidyne provides accurate control of grinder wheel surface speed by automatically compensating for wheel wear. The system consists of a Varidyne Power unit, an AC induction type Varidyne Motor and necessary controls. The Varidyne Motor, which drives the wheel, provides vibration-free, variable speed operation with inherent overspeed protection. An adjustment is provided to set the grinding speed desired. Once set, the grinding speed is automatically maintained regardless of wheel wear by increasing the wheel speed as the diameter reduces . . . (*From new 8-page bulletin Form F-1952, U. S. Electrical Motors, Inc., Milford, Conn.*)

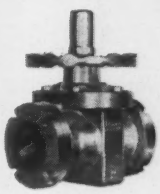
CIRCLE 281 ON READER-SERVICE CARD

FOR MORE INFORMATION ON
ANY PRODUCT USE
READER-SERVICE CARD

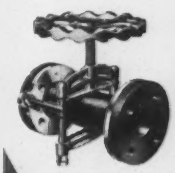
Wet or dry—
It will flow through a
FLEX-VALVE



Nothing surpasses Farris Flex Valves for efficiency and reliability when you're moving corrosives and abrasives through process lines. Unlike other valves, Flex Valve becomes an integral part of your pipe line with **full pipe capacity** . . . with nothing to block flow . . . with no internal parts! Flex Valve is the simplest valve made **—guaranteed** not to plug!

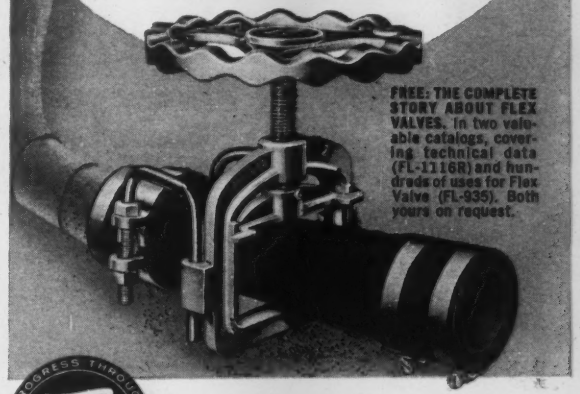


Why buy a valve that is a compromise? Specify Flex Valve—the original, the only valve with full opening, no obstructions. Nothing less will give you maximum operating results.



USE FLEX VALVES FOR: Ammonia • Abrasive water slurry • Acetic acid slurry • Bordeaux mixtures • Butyral flakes • Chlorinated solvents • Carbolic acid, phenol • Copper sulfate and lime • Electrolyte—16% H_2SO_4 • Hydrochloric acid • Hydrofluoric acid • Liquid latex • Muriatic acid • Phosphate rock and sand • Potassium cyanide • Sodium chloride brine • Stannic chloride • Sulphuric acid • Sulphuric Trioxide, dry • Zinc sulfate • and many other uses.

See our Display at the ISA show . . . Booth 558



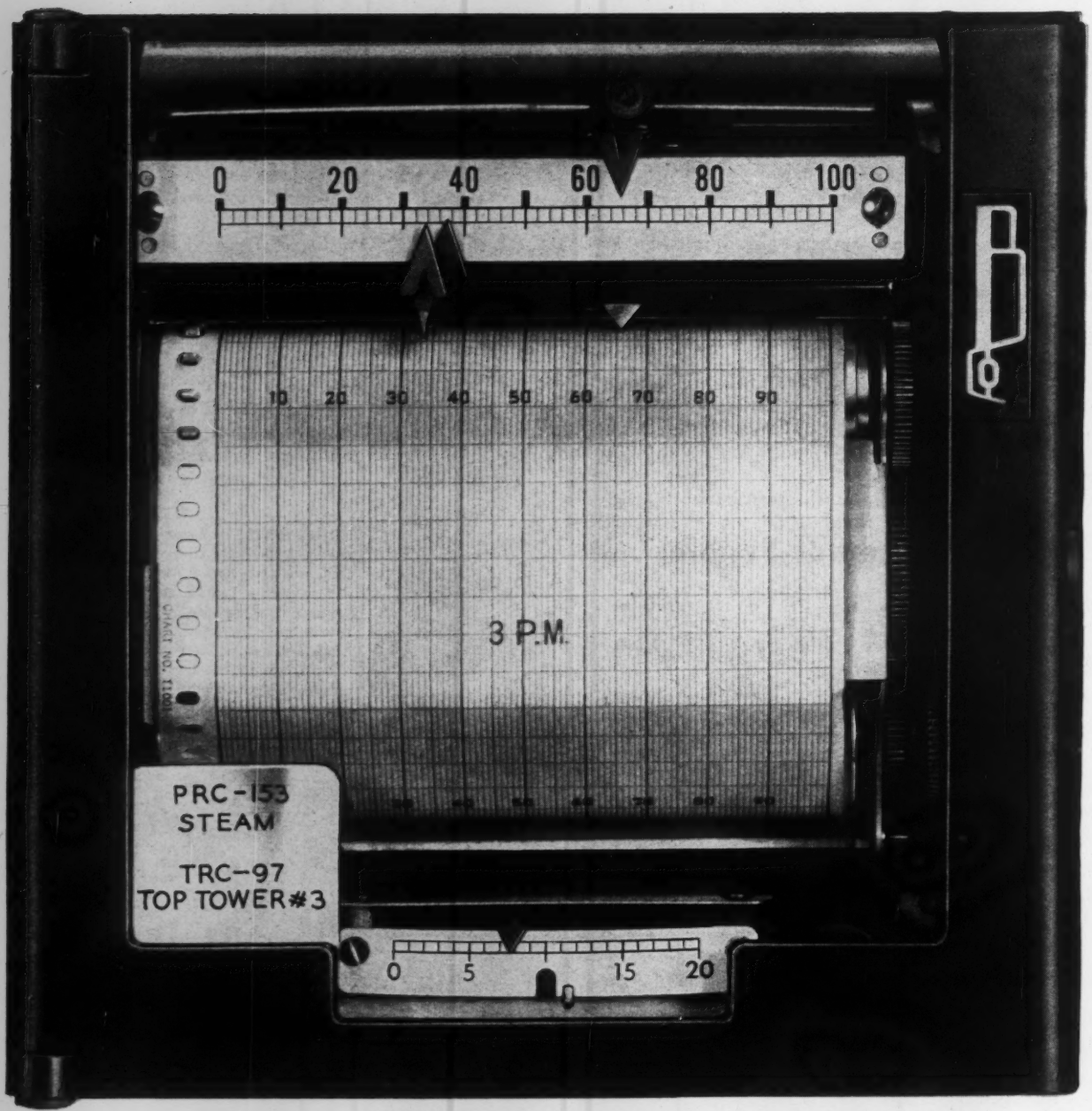
FREE: THE COMPLETE STORY ABOUT FLEX VALVES. In two valuable catalogs, covering technical data (FL-1116R) and hundreds of uses for Flex Valve (FL-935). Both yours on request.

PROGRESS THROUGH HONEST PURPOSE
Farris®
Over 25 Years in Industry's Toughest Service
FLEXIBLE VALVE CORP.
706 Commercial Ave., Palisades Park, N.J.

AFFILIATES: FARRIS ENGINEERING CORP. · FARRIS COMBUSTION CONTROLS CORP. · FARRIS UNIVERSAL MACHINE CORP. · FARRIS INDUSTRIES CANADA LTD., LONGUEUIL (MONTREAL) · FARRIS ENGINEERING LTD., LONDON, ENGLAND · MIDLAND INDUSTRIES LTD., WOLVERHAMPTON, ENGLAND

CIRCLE 59 ON READER-SERVICE CARD

NEW..



ACTUAL SIZE. New Series 670 Metagraphic is ideal for graphic panel applications, occupying panel space only 7" wide by 7⅛" high. Fits into 6" by 6" panel cutout. Typical 670 Series models available, include:

- 1-Pen, 2-Pen, or 3-Pen Receiver
- Manual-Automatic Control Station
- Manual-Cascade Control Station
- Manual-Automatic-Cascade Control Station
- Single-Case Cascade Control Station

here's the pneumatic receiver you asked for!

Bristol's new 4-inch-chart Metagraphic receiver

is the easiest yet to install, operate, and service

Never before has a 3-15 psi pneumatic receiver been designed with such exacting, meticulous attention to the needs of the graphic panel designer, the instrument user, and the instrument maintenance man.

Bristol's new Series 670 Metagraphic receiver brings you the plug-in versatility and operating convenience—made famous in previous Metagraphic pneumatic receivers—plus the increased legibility and accuracy of a 4-inch strip chart, plus these big new features:

Simplified control switching between functions... allows the easiest start-up procedure for either the common manual-automatic station or the more complex, single-case cascade control station models. Intermediate "seal" position has been eliminated. Just adjust process to line-up color-coded indicators and switch to automatic or cascade operation as desired.

Uniform control switching . . . all receiver models have the same switch positions for the various types of control—cascade position, 3 o'clock; manual position, 6 o'clock and automatic position at 9 o'clock.

Simplified chart change and inking . . . chart changing is a one-hand operation. A new chart can be slipped into place in an instant. The capillary inking system can be refilled from the front of the receiver.

And the new Metagraphic receiver gives you other outstanding features such as rectilinear chart coordinates for easiest reading, easy connections for any type of control, either field or receiver-mounted controllers; and sparkless, mercury-switch disconnect of electrical circuit when chassis is removed.

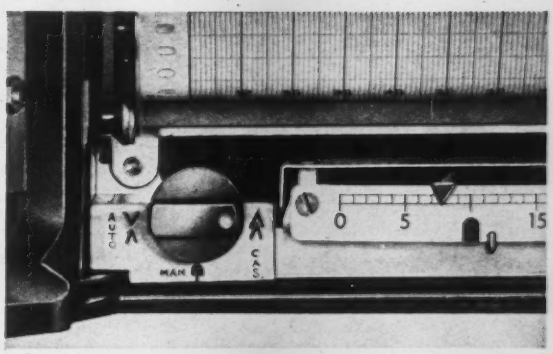
Get the complete story on the new Bristol Metagraphic receiver today. Write The Bristol Company, 113 Bristol Road, Waterbury 20, Conn., a Subsidiary of American Chain & Cable Company, Inc. 0.42

ACCO

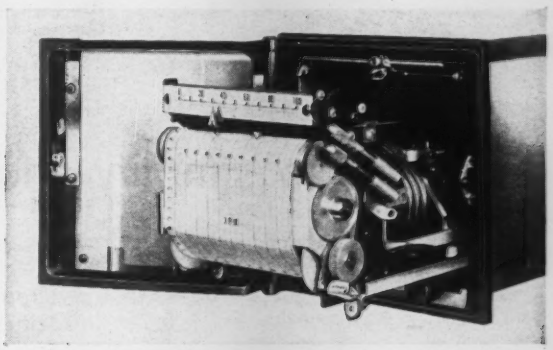
BRISTOL

...for improved production through measurement and control

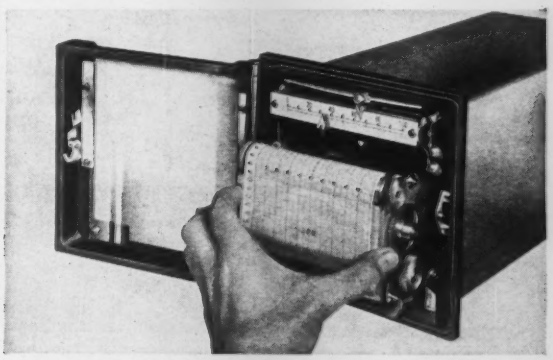
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



Simplified control switching is keynote of new receiver's design. For instance: uniform switch positions on all models avoid operator confusion in multi-receiver installations; simple alignment of color-coded pointers and a single switching operation put complex automatic or cascaded systems "on stream."



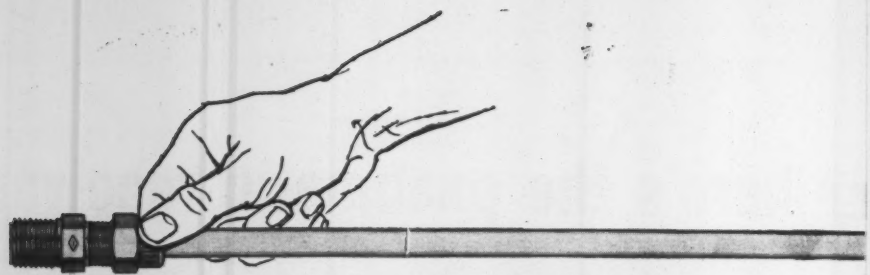
Complete "plug-in" service continuity. Entire plug-in receiver chassis is instantly replaceable with spare for complete continuity of service. Control functions are not disturbed when receiver chassis is removed.



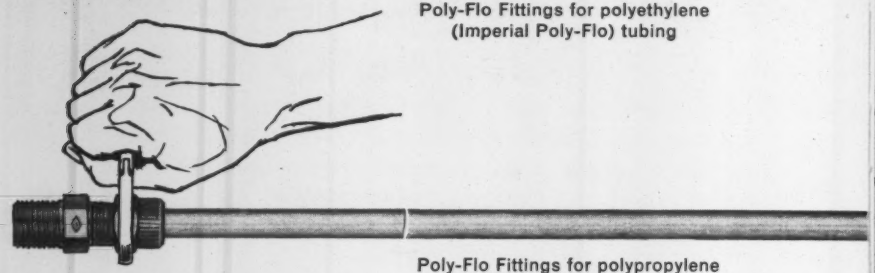
Easiest to service . . . For instance: Easily removable chart drive mechanism—a one-handed operation—permits exceptionally fast chart replacement; just slip out drive, replace with spare, replace paper in original drive at leisure.

Come in and see us at Booths 814-824 at the I.S.A. Show

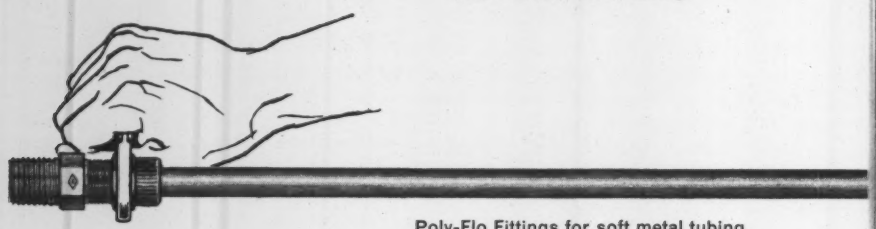
CIRCLE 60 ON READER-SERVICE CARD



Poly-Flo Fittings for polyethylene
(Imperial Poly-Flo) tubing



Poly-Flo Fittings for polypropylene
(Imperial Impolene) tubing



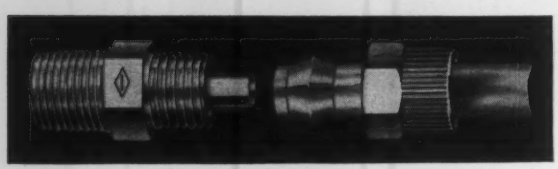
Poly-Flo Fittings for soft metal tubing

New way to simplify and save on low-pressure circuitry

Now you need only *one* fitting for low-pressure circuitry—whether you use plastic, thermoplastic or soft metal tubing. With that *one* fitting—Imperial Poly-Flo®—you economize on materials and economize on simplified assembly.

The unique design of Poly-Flo Fittings eliminates inconvenient inserts. Assembly is quick and easy. Material and time costs are lowered. Fittings hold beyond burst pressures of the tubing, assuring dependable assemblies for instrumentation as well as many hydraulic and pneumatic circuitry applications.

When used with polyethylene tubing, Poly-Flo Fittings are simply finger-tightened, saving additional time and money. No tools except a wrench are ever needed with other tubing.



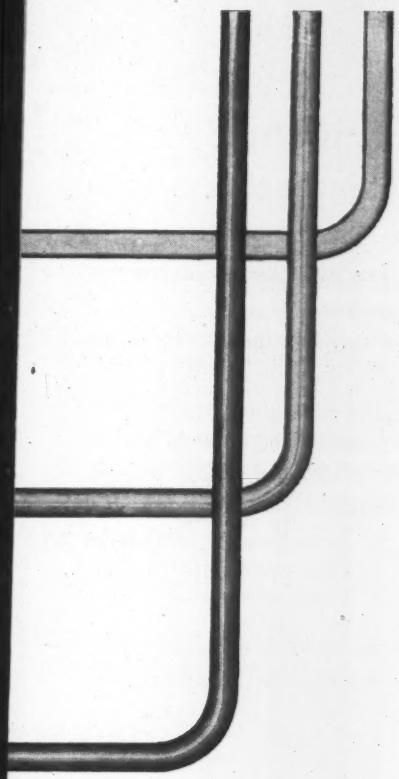
POLY-FLO

IMPERIAL EASTMAN

Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

Imperial-Eastman Corporation (Canada) Ltd., Barrie, Ontario • Imperial-Eastman, S.A., Apartado Postal 26544, Mexico 13, D.F.

CIRCLE 61 ON READER-SERVICE CARD

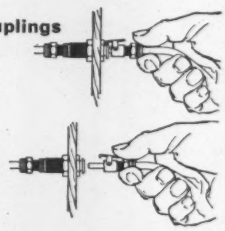


Poly-Flo Fittings available in variety of styles, sizes

Poly-Flo Fittings include straight unions, connectors, half unions, bulkhead unions, reducing adapters, elbows, tees and Kwik-Connect valves. Sizes to ½ in., tube o.d. For complete information, write for Bulletin 3025-F.

Kwik-Connect Couplings

Push . . . the fitting snaps together, forming a reliable, pressure-tight connection with 2-way flow. Click . . . it's disconnected—flow instantly cut off.



FITTINGS

IMPERIAL — EASTMAN

IGS EVENTS

August 22-25

Western Electronics Show and Convention (WESCON), Cow Palace, San Francisco, Calif. For information write Don Larson, WESCON manager, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

August 28-30

21st Annual Appalachian Gas Measurement Short Course, West Virginia University, Morgantown, W. Va. For information write Prof. R. E. Hanna, University of West Virginia, Morgantown, W. Va.

September 5-8

Eleventh National Chemical Exposition, International Amphitheatre, Chicago, Ill. For information write Chicago Section American Chemical Society, 86 E. Randolph St., Chicago 1, Ill.

September 6-8

International Symposium on Transmission and Processing of Information—IRE Massachusetts Institute of Technology, Cambridge, Mass. For information write Peter Elias, MIT, Rm. 26-347, Cambridge 39, Mass.

September 6-8

National Symposium on Space Electronics and Telemetry—IRE, Albuquerque, N. M. For information write Dr. B. L. Basore, 2405 Parsifal, N.E., Albuquerque, N. M.

September 11-15

Marine Sciences Conference, sponsored by American Society of Limnology and Oceanography and ISA, Woods Hole, Mass. For information write Instrument Society of America, Penn-Sheraton Hotel, 539 William Penn Pl., Pittsburgh 19, Pa.

September 11-15

Third International Congress on Cybernetics, Namur, Belgium. For information write Secretary, Association Internationale de Cybernetique, A.S.B.L., rue Basse-Marcelle, 13, Namur, Belgium.

September 11-15

ISA Fall Instrument-Automation Conference and Exhibit, Memorial Sports Arena and Biltmore Hotel, Los Angeles, Calif. For information write William Kushnick, Instrument Society of America, Penn Sheraton Hotel, 539 William Penn Pl., Pittsburgh 19, Pa.

September 20-21

Joint Industrial Electronics Symposium, IRE, ISA, AIEE, Bradford Hotel, Boston, Mass. For information write H. O. Painter, Jr., General Radio Co., West Concord, Mass.

September 24-26

International Congress of Automation, Turin Polytechnic, Turin, Italy. Write Secretary, Associazione Nazionale Italiana per l'Automazione (A.N.I.P.L.A.), Piazza Belgioioso 1, Milan, Italy.

FACT

Flexible Automatic Circuit Tester

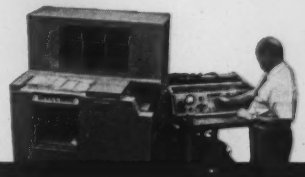
Cut programming time for circuit tests

Hughes has developed a general purpose, high-capacity test unit that dramatically cuts the time and money involved in circuit continuity and high potential testing. □ Called **FACT** (Flexible Automatic Circuit Tester), this unit uses standard IBM systems. This feature makes programming easier. And when the units to be tested have been built with IBM wiring lists, the entire test procedure can be automated. □ With **FACT** you eliminate the costs of developing special purpose test equipment. You can program complete and varied tests on an unlimited number of circuits. You can cut trouble-shooting time. And, since **FACT** is self-calibrating and self-testing, you can substantially increase the confidence level of the circuit test. □ **FACT** is production proven and available today. With three different **FACT** models (2 card programmed and 1 tape programmed) Hughes can meet every circuit testing problem. Inquire today. Write to L. W. Risner, Hughes El Segundo, L.A. 45, California. Or, better yet, call him at ORegon 8-0361, Ext. 1652.

Creating a new world with Electronics

HUGHES

HUGHES AIRCRAFT COMPANY



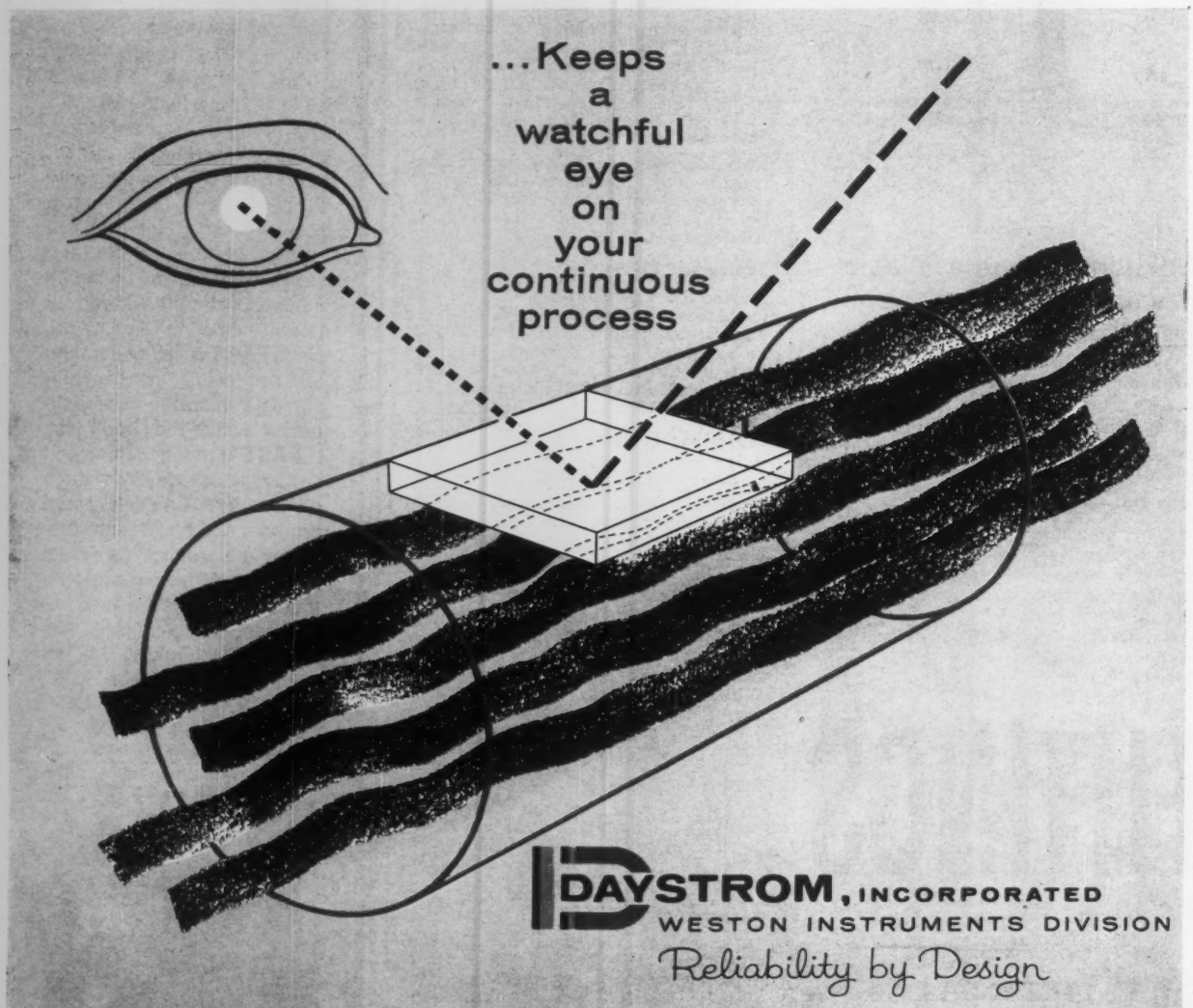
CIRCLE 62 ON READER-SERVICE CARD

NEW DAYSTROM INDEXOMETER®

Now you can take advantage of continuous, on-stream monitoring of your process with the new Daystrom INDEXOMETER. By "looking" into a stream through a special window, it measures changes in the refractive index of binary mixtures—clear or opaque—or fluids with particles in suspension. Minute variations in concentration can be detected, measured and controlled.

Advantages are obvious. The INDEXOMETER permits continuous analysis of flowing liquid streams without process interruption . . . eliminates time-consuming laboratory analysis . . . can even help you convert from batch to continuous process.

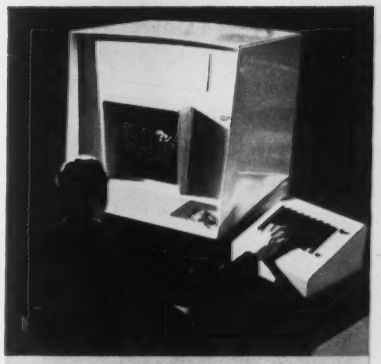
Call our field engineers to learn how the INDEXOMETER can help increase your yield, improve quality and reduce operating costs by simplifying your process control. Write or phone: Daystrom, Incorporated, Weston Instruments Division, 229 Manchester Road, Poughkeepsie, New York. *International Sales Division, 100 Empire St., Newark 12, N. J. In Canada: Daystrom Ltd., 1480 Dundas Highway East, Cooksville, Ontario.*


...Keeps a watchful eye on your continuous process
DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

SEE THE INDEXOMETER IN OPERATION—VISIT BOOTH 614...ISA SHOW

CIRCLE 14 ON READER-SERVICE CARD

"need to know now" applications of the RD-900 Random Access Storage and Display System.

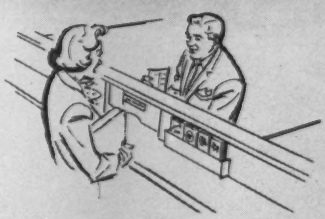


The RD-900 provides a random access file of up to 495 million, or more, bits with access to information in less than 3/10 of a second. It is adaptable to virtually all existing computer systems, or may be used as an independent random access storage and display unit. The display device is a high resolution, flicker-free, 21″ direct view storage tube capable of exhibiting up to 12,800 characters or symbols. Alphanumerics, arbitrary or abstract symbols, graphs, charts and maps may be displayed.

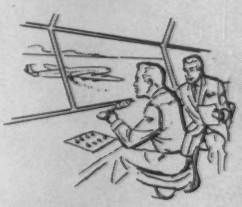
Its primary application is any situation where instant access and simultaneous display of volume data are required.

Typical applications are illustrated.

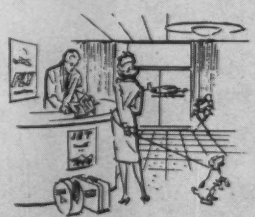
1. **Account Servicing** . . . for banks, utilities and other service organizations. Customer inquiries may be answered in seconds without interrupting the normal accounting cycle.
2. **Air Traffic Control** . . . where accurate and vital information is required at a moment's notice . . . allows alpha-numeric display superimposition on chart or map indicating actual aircraft position.
3. **Ticket and Reservation Control** for rail, ship, plane, hotel and associated industries . . . would eliminate overselling of space . . . with graphic presentation, passengers could actually see which cabin, seat, or room was being assigned.
4. **Immediate Stock Information** to brokerage houses, including current transactions, past transactions as well as trends that establish buy or sell situations.
5. **Military Command Control** situations where a large volume of data must be digested and decisions based on such data must be reached within an extremely critical time period.



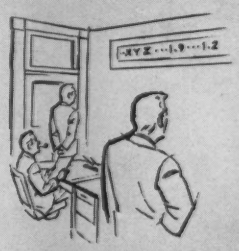
Account Servicing



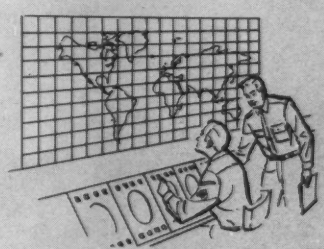
Air Traffic Control



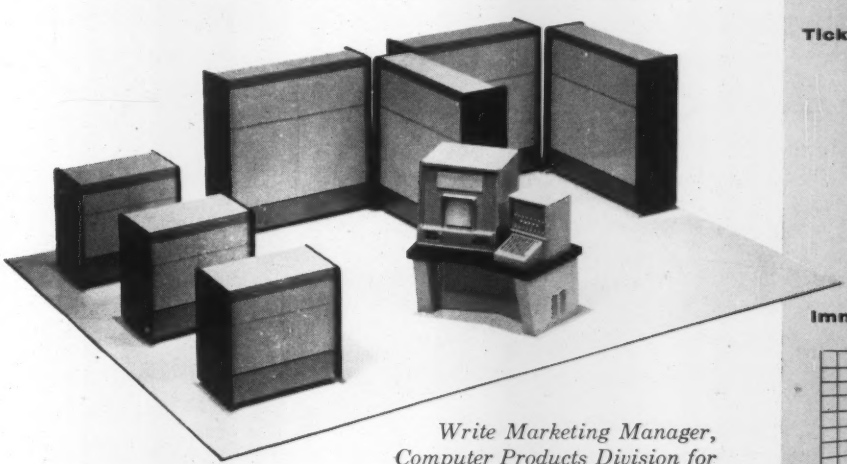
Ticket and Reservation Control



Immediate Stock Information



Military Command Control



Write Marketing Manager, Computer Products Division for complete information.

LFE COMPUTER PRODUCTS DIVISION

LABORATORY FOR ELECTRONICS, INC.

1079 COMMONWEALTH AVE. • BOSTON 15, MASSACHUSETTS

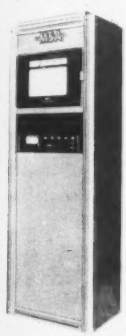
CIRCLE 64 ON READER-SERVICE CARD

CIRCLE 65 ON READER-SERVICE CARD →

MSA Instruments apply all these principles for dependable process stream analysis

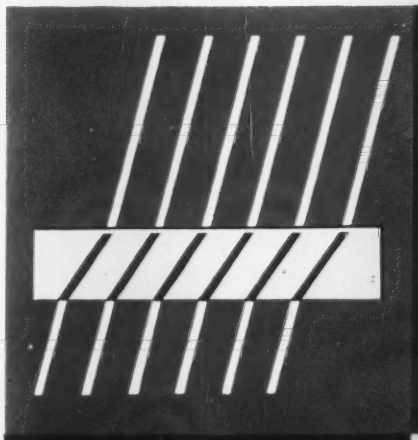
Ionization:

Now MSA simplifies control of contaminants in the parts per *billion* to parts per million range. The M-S-A® BillionAire* Analyzer is the hypersensitive instrument. • It's already at work in air pollution studies, process monitoring and continuous measurement of toxic gases in air. • Except when measuring oxygen in low concentrations, the instrument is sensitized for a specific problem by reacting the gas of interest with a reagent system to convert that gas to an aerosol. The aerosol passing through the ionization chamber changes its electrical conductivity which unbalances a bridge circuit in proportion to concentration. This in turn is indicated by an integral meter or recorder. • This new ionization detection system displays high sensitivity for acid gases such as HCl, HF, SO_2, HCN, N_2O_4; alkaline gases such as ammonia, hydrazene, UDMH, amines; halogenated hydrocarbons such as carbon tetrachloride, trichlorethylene, ethylene chlorine, ethylene bromide; and many others. • The versatility of our big picture approach to instrumentation is symbolized in the adjoining illustrative panels. Please write for our new M-S-A BillionAire Analyzer bulletin. Or for any of our other process stream analyzer literature.

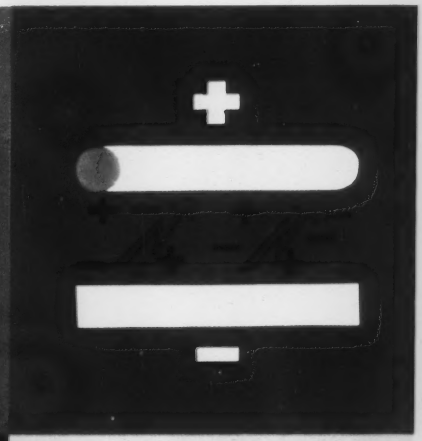


Mine Safety Appliances Company, Pittsburgh 8, Pennsylvania

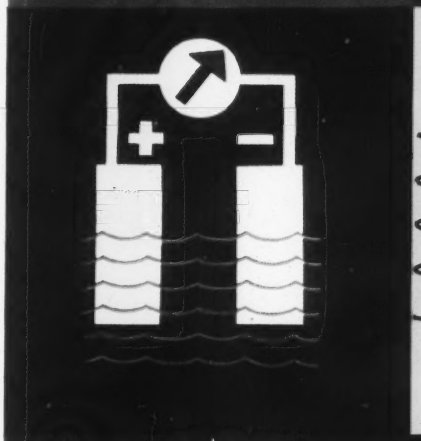
*Trademark



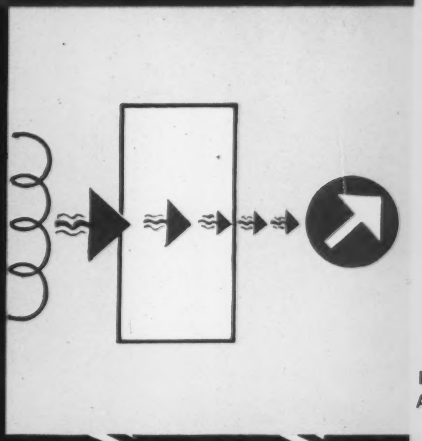
Refraction



Ionization

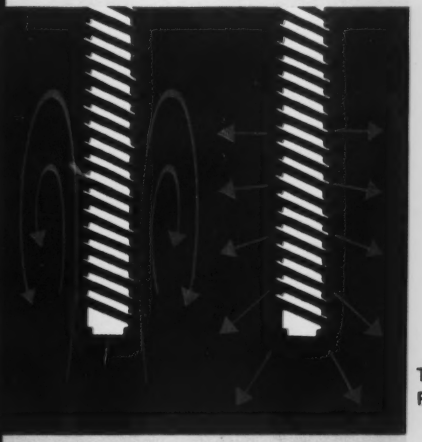


Depolarization

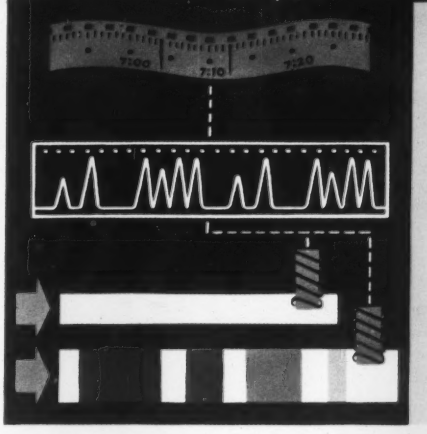


Infrared Analysis

Catalytic Combustion



Thermal Properties



Chromatography

INSTRUMENT DIVISION
Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

MSA

*Trademark

M-S-A® Gas Chromatograph

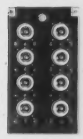
M-S-A® LIRA® Infrared Analyzer Model 200

M-S-A® LIRA® Infrared Analyzer Model 300

M-S-A® BillionAire* Analyzer

M-S-A® Process Refractometer

M-S-A® Inert Gas Analyzer



M-S-A® Combustible Gas Analyzer

M-S-A® Thermatron Analyzer

M-S-A® Oxygen Indicator

M-S-A® Water Vapor Recorder

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters

Here is Why!

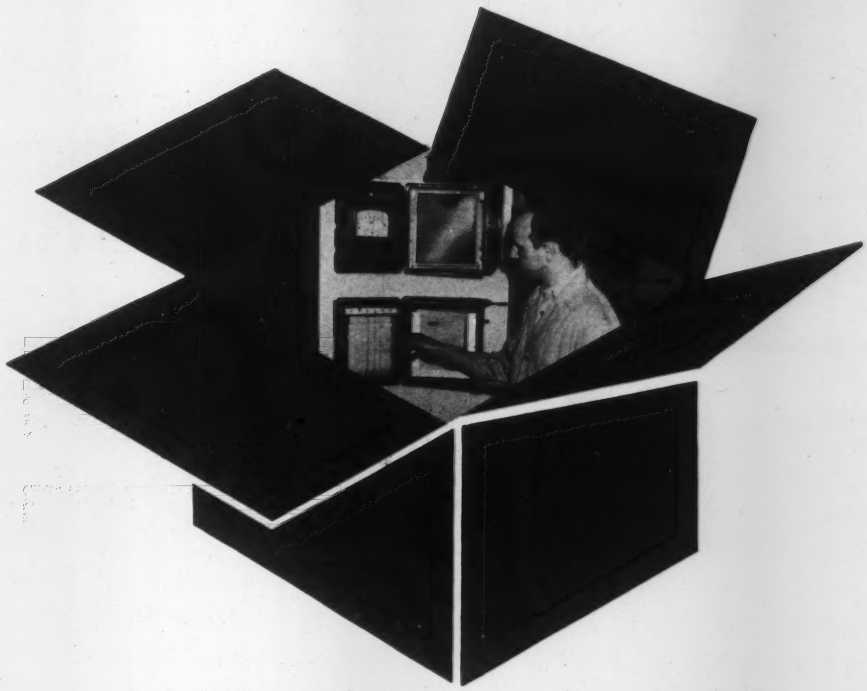
You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

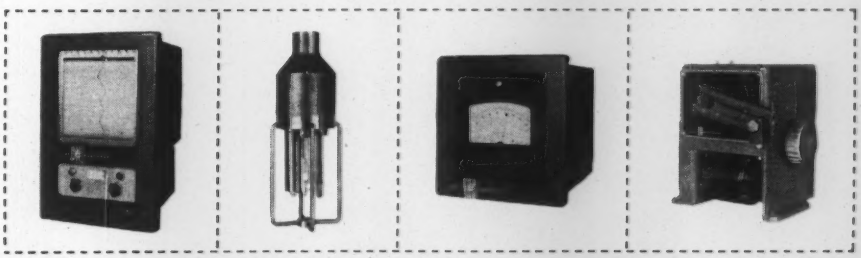
← CIRCLE 65 ON READER-SERVICE CARD



Why settle for less than a complete pH control package...

. . . when you can get *all* the needed process-proved equipment — from electrodes to valve drive units — designed and manufactured by L&N? Whether you need electric, electro-pneumatic or pneumatic control, we take *complete responsibility* for the successful operation of your equipment package.

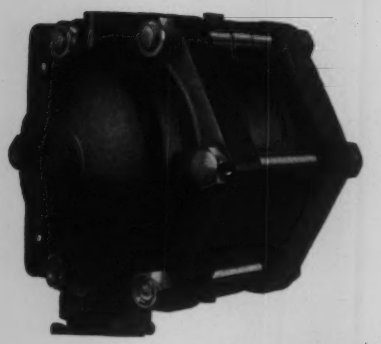
And to assure you the correct instrumentation, our staff of experienced engineers checks all the factors involved in your particular control problem . . . factors such as agitation, flow rate and its variations, changes in acidity, retention, detection lag, selection of the control point and the rangeability of feeding devices. By analyzing these factors, our engineers determine the type of control applicable to your particular problem . . . whether it involves waste treatment, cooling tower water, pH of production agents, or other.



If you want complete pH control . . . *with a single source of responsibility* . . . it will pay you to call your nearest L&N Field Office, or write 4955 Stenton Ave., Philadelphia 44, Pa.

LEEDS & NORTHRUP *Pioneers in Precision*

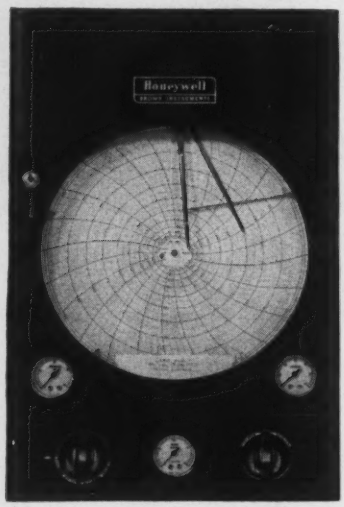
CIRCLE 66 ON READER-SERVICE CARD



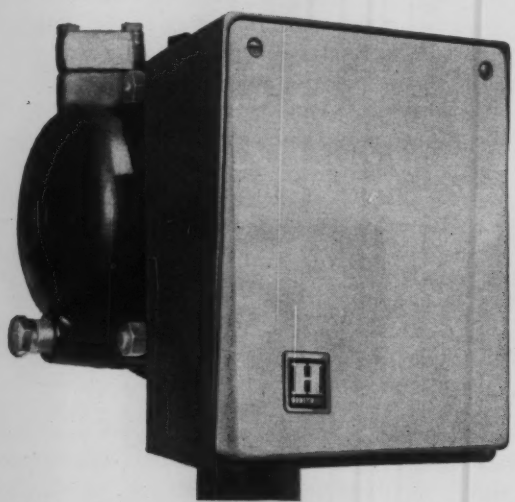
Honeywell Bellows Meter brings

Six of many ways you can use the bellows meter

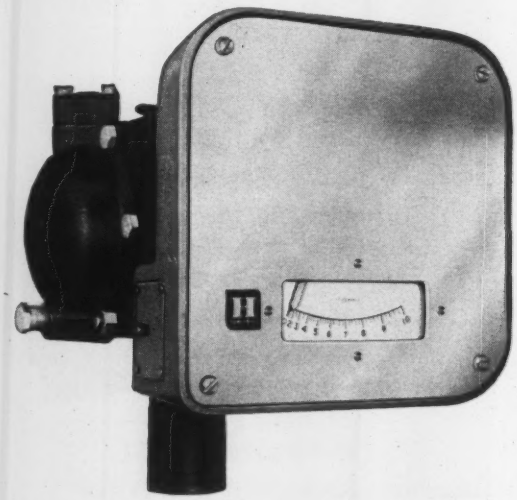
As a Recorder or Integrator—Recorders can have one, two or three pens, with the second and third pens actuated by thermometer or pressure elements. A single-pen recorder is shown above. You can get integration, too.
Write for Specification S 292-2a.



As Recording Controllers—You can get recorders with pneumatic ON-OFF, 10% *Throttlor*, 150% *Throttlor* with manual reset, or *Air-O-Line* (150% proportional band-plus-automatic reset) control. A single-pen pneumatic controller with integral bypass is shown above.
Write for Specification S 292-2a.

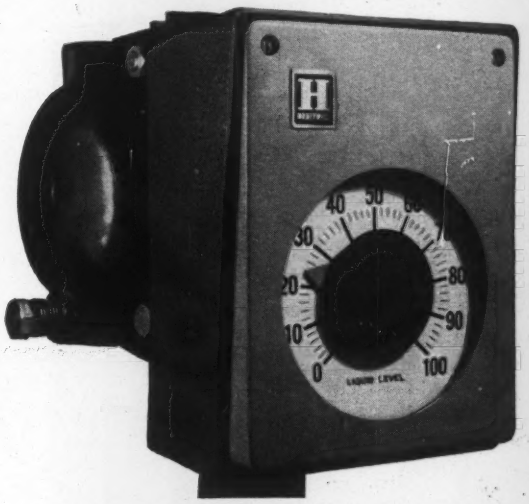


As a Non-indicating Pneumatic Transmitter—Use this non-indicating transmitter when you don't need indication at the point of measurement, and when the measured variable is to be transmitted to remotely located instruments.
Write for Specification S 230-1.



As an Electric Transmitter—You can use this *ElectriK Tel-O-Set* electric flow and liquid level transmitter with indicators, recorders, and controllers, with data handling systems, or with millivolt receivers. Field indication, as shown, is optionally available.
Write for Specification FS 301-7.

new versatility to flow or liquid level measurement



As an Indicating Pneumatic Transmitter—Gives you indication at the point of measurement, plus pneumatic transmission. Easy-to-read scale, and large indicating pointer. Case is only 4 by 7 by 9 inches.
Write for Specification S 230-1.

As a Dial Indicator—Six-inch dial indicator gives easy, accurate readings at point of measurement. This meter-indicator is designed specifically for field indication.
Write for Specification S 224-1.

You can use the Honeywell Bellows Flow Meter as a recorder, controller, indicator or transmitter . . . pneumatic or electric. Use it for accurate, low-maintenance metering of flow—for steam, water, gas, oil or other fluids—or for liquid level measurement. In all of its many forms, with all of its performance advantages and operating economy, it is the most advanced flow and liquid level meter available today.

Some outstanding features:

Stability—The meter body will operate over an ambient temperature range of —40° to 250°F. Over a range from —32° to 150°F. the accuracy will not change more than 0.5%.

Leakproof construction—Hydraulically formed stainless steel bellows eliminate any chance of leakage between fill and process fluid.

Quick, easy damping—Rectangular orifice pulsation check varies the speed of response over a ratio of 20 to 1. Adjustment is essentially linear and can be made from outside the meter body while the instrument is operating.

Sensitivity and accuracy are well within the required limits of measurement and control on applications for which these instruments were designed.

Convenience—Change range easily in the field by replacing a single range spring assembly. The meter body is self-venting when measuring liquids and installed below the flow line; self-draining when measuring gas and installed above the flow line.

There are models of the Honeywell Bellows Flow Meter available in many ranges, for every application. Your nearby Honeywell field engineer can give you complete details and help you select the correct model for your application. Call him today.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

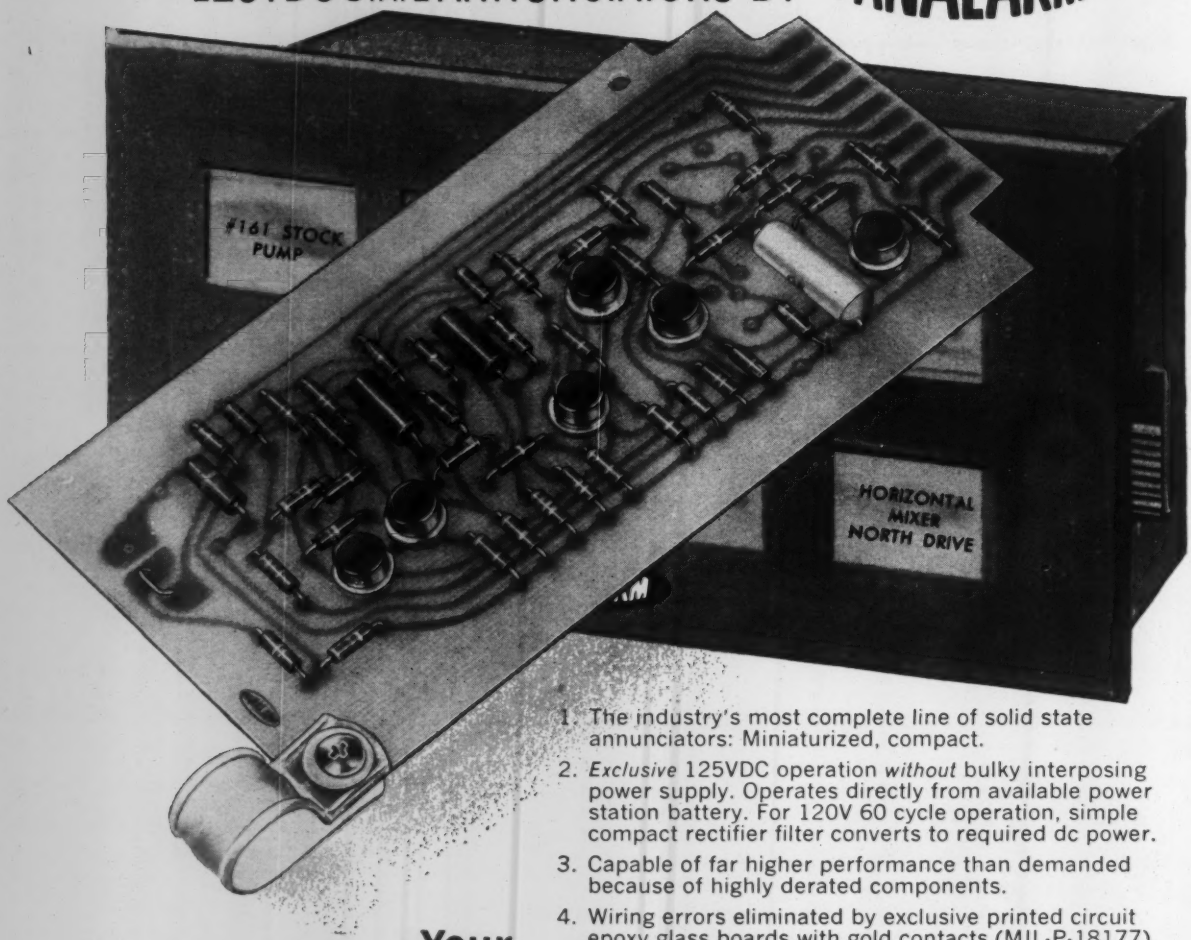
SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

CIRCLE 67 ON READER-SERVICE CARD

designed for decades of reliability

PANASTAT®
125VDC SOLID STATE ANNUNCIATORS BY PANALARM®



Your 6 Major Benefits

1. The industry's most complete line of solid state annunciators: Miniaturized, compact.
2. *Exclusive* 125VDC operation *without* bulky interposing power supply. Operates directly from available power station battery. For 120V 60 cycle operation, simple compact rectifier filter converts to required dc power.
3. Capable of far higher performance than demanded because of highly derated components.
4. Wiring errors eliminated by exclusive printed circuit epoxy glass boards with gold contacts (MIL-P-18177).
5. Readily obtainable . . . highly visible . . . standard 6S6 double contact bayonet 3-watt lamps.
6. Exclusive *safety* factor. Low energy control circuits feeding thru signal contact provide intrinsic safety. Thus the possibility of ignition in hazardous locations is minimized.

Panastat annunciators by Panalarm offer a new high in performance and a new low in maintenance. This is because there are no moving parts and because components are highly derated.

Your Panalarm Sales Engineer will be pleased to discuss Panastat Solid State Annunciators with you in complete detail. Call him today. Sales and engineering offices throughout the world.

ISI PANELLIT

ANNUNCIATORS · CONTROL PANELS · DATA SYSTEMS

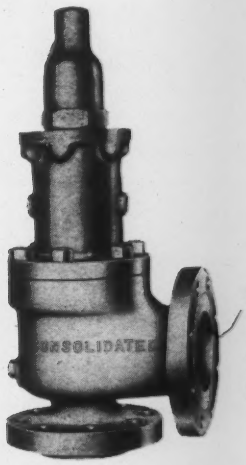
A division of ISI Incorporated

7401 North Hamlin Avenue, Skokie, Illinois · Phone ORchard 5-2500

CIRCLE 68 ON READER-SERVICE CARD

top

CONSOLIDATED SAFETY RELIEF VALVES have a special "O" Ring Seat Seal that stops leakage completely



Consolidated Safety Relief Valves are available in both Standard and Balanced Bellows design for extreme corrosive applications.

tightness

The Seal is a resilient ring set in the valve disc. It maintains no-leak tightness by contact with a specially curved seating surface on the valve nozzle, yet does not carry the seat load imposed by the valve spring.

Tightness is maintained at operating pressures far closer to set pressure than with metal-to-metal seats alone. Tight closure is as efficient after "simmer" as on normal blowdown. Piping strains are absorbed far better by the resilient seal than all-metal seating. If the tough seal is ruined by entrained abrasives, replacement is easy. Seals are available in materials that resist corrosive fluids. Maintenance costs are greatly reduced.

Standard Consolidated Safety Relief Valves have an eductor tube that removes pressure from the closed bonnet. Only the spring controls valve action. You get guaranteed capacity ratings and highest dependability—absolute protection for personnel and equipment. Additionally, there is the economy of converting the Standard valve to the Balanced Bellows type in your own shop. Get complete details. Write for Bulletin 1940.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

CONSOLIDATED SAFETY RELIEF VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

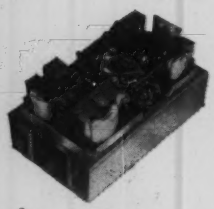
Valve Division • Tulsa, Oklahoma

Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

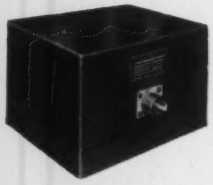
CIRCLE 69 ON READER-SERVICE CARD

NAME THE CHARACTERISTICS* YOU WANT IN STATIC POWER

* Large Overload Capacity: 200%

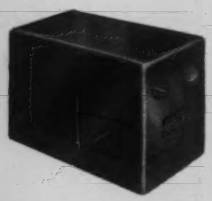


* Low Power Factor: 0.3 lagging to unity

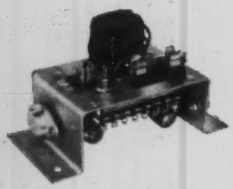


* Dual Output: Single or Three Phase

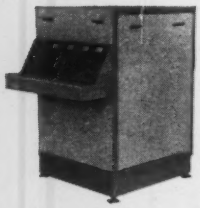
* Wide Temperature Range: −55° C to +125° C



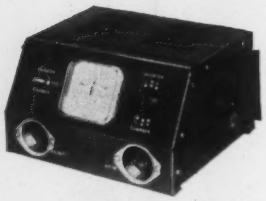
* Accurate Frequency Regulation: 400cps. ± 0.25%



* High Efficiency: 85% minimum



* High Voltage Output: 150 KV



* Dual-Purpose: Charger and Inverter

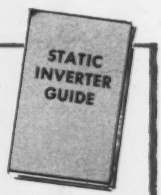
...for • industrial telemetry systems • remote or emergency signalling, warning or measuring systems • automated machine tools • microwave communication equipment

... wherever circuit interruption cannot be tolerated

You probably would not need all of the design/performance characteristics listed above in a single inverter. But today, after a three-year, full-scale development program, Hamilton Standard static inverters offer a wider range of proven design and operating characteristics than any you can buy—individually and in combinations. This means that Hamilton Standard static inverters can deliver the extra reliability, long maintenance-free service and quick starts heretofore unattainable with rotary power supplies.

If your equipment calls for a power supply with exceptional reliability, tell us about your complete requirements. We can provide the inverter you need.

What are inverters ... how, when and where to use them. A comprehensive aid for engineers. For your copy, write: Hamilton Standard Electronics, Broad Brook, Conn.



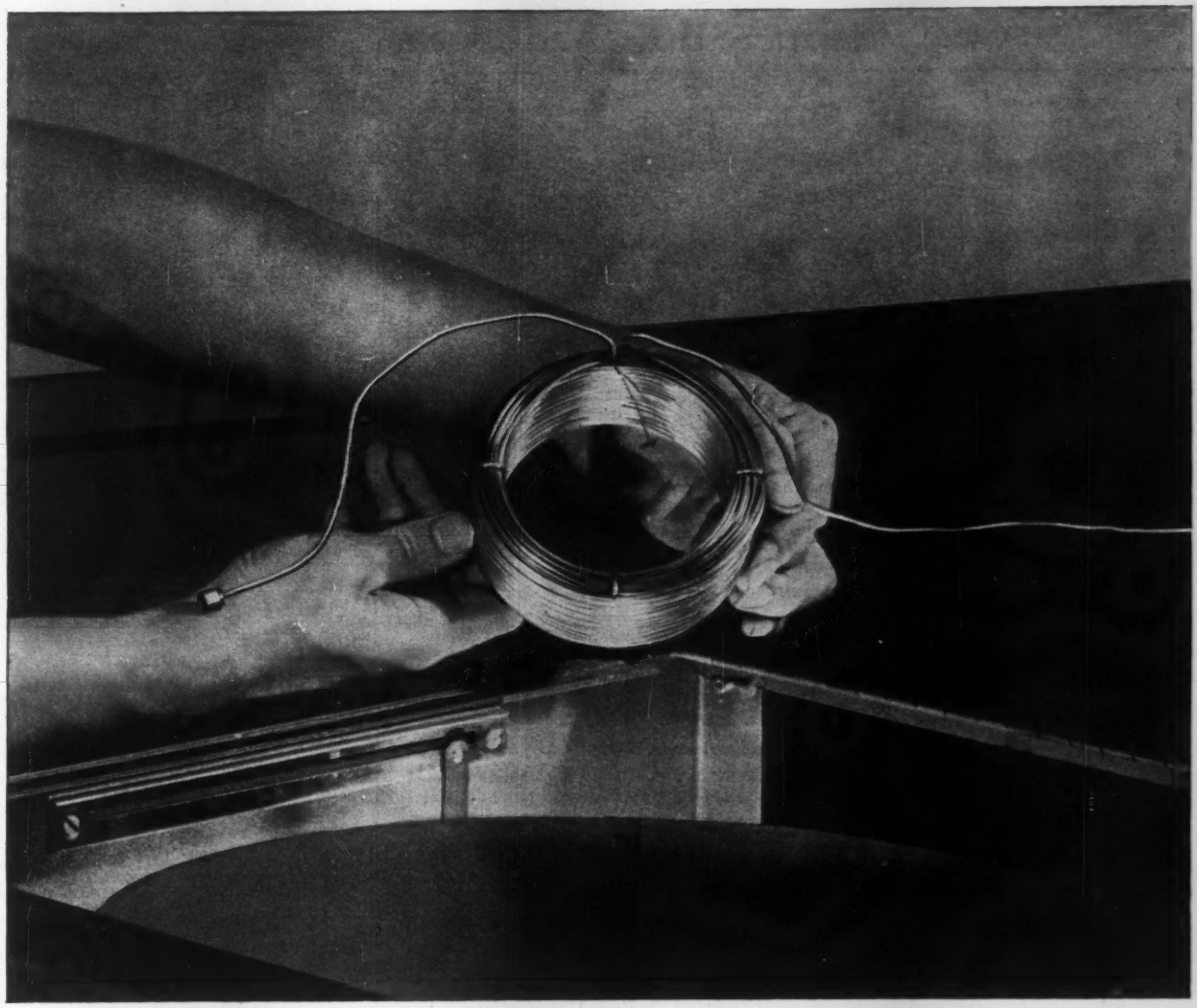
UNITED AIRCRAFT CORPORATION

HAMILTON STANDARD DIVISION

ELECTRONICS

CIRCLE 70 ON READER-SERVICE CARD

Tomorrow's tubing technology—today



Photograph courtesy Barber-Coleman Company

You get precise partitioning in gas chromatography tubing by Superior

The reason is a composite of many outstanding advantages: desirable inner surface, uniform bore and size, good corrosion resistance, high temperature resistance, ease in fabricating and bending; also good heat transfer characteristics and the ability to receive a wide variety of coatings.

Superior offers tubing for gas chromatography columns in Types 304, 316, 321 and 347 stainless steels and in 30% cupronickel. Capillary tubing sizes include 1/16 in. OD x .010 in., .016 in. and .020 in. ID. ODs to 1/8 in. and intermediate and larger IDs are available. We also make tubing for miniature columns, the most common size being .020 in. OD x .010 in. ID. Tubing for packed columns is available in 1/4 in. OD x 3/16 in. ID. And remember if you need small-diameter tubing for other purposes, we can help you too. We produce more than 120 analyses in sizes from .010 to 5/8 in. OD in quantities from 50 to over 1,000,000 ft. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa. Write for Bulletin 110—"Tubing for Gas Chromatography."

Superior Tube ST

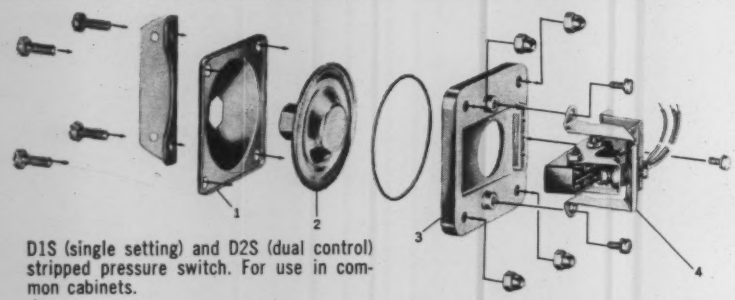
The big name in small tubing

NORRISTOWN, PA.

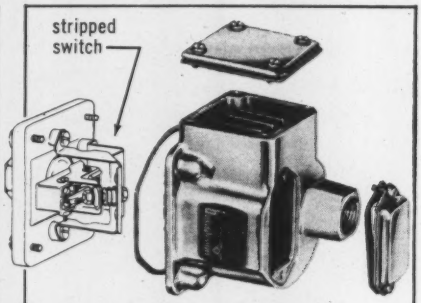
West Coast: Pacific Tube Company, Los Angeles, California

CIRCLE 71 ON READER-SERVICE CARD

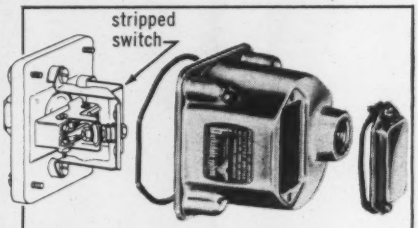
How to put 50% more accuracy into a pressure switch at 25% lower price



D1S (single setting) and D2S (dual control) stripped pressure switch. For use in common cabinets.



D1T (single setting) pressure switch with integral terminal block. Weatherproof housing.



D1H (single setting) and D2H (dual control) pressure switch with standard housing. Weatherproof.

The accepted standard of accuracy in pressure switches is ±1%. The new Barksdale diaphragm pressure switches are guaranteed for ± ½ % set and re-set accuracy (±0.2% if required). This instrument accuracy, unique proof (test) pressure characteristics, and remarkably easy servicing are accomplished by the use of a "basic unit" diaphragm assembly to which components are attached as required. The erector set principle permits production economies that are reflected in substantially lower prices. The entire concept of Barksdale pressure switches is the result of desired specification improvements as suggested by representatives of varied industries who were consulted before designing was begun.

The versatile basic unit

A leakproof, welded-metal sensing element (No. 2 in the photograph above) is surrounded by a heavy protective capsule (Nos. 1 and 3) which is independent of the sensing and switching elements. The hex of the pressure connection fits into a hex opening in the base of the capsule, preventing damage to the diaphragm should the unit be twisted during installation or removal. The standard pressure connection is ¼" npt female pipe fitting; ½" npt fitting is available when specified. The latter was requested by the petroleum industry to facilitate removal of paraffin accumulation and to permit attachment of switches directly to ½" pipe.

Diaphragms easily removable

Diaphragms may be removed without disturbing switch wiring, thus making it possible to change diaphragms to accommodate varying pressure requirements or to substitute diaphragms of different metals as fluid characteristics may demand. This feature cuts inventory costs for original equipment manufacturers because they need stock only diaphragms to meet their various pressure requirements rather than to stock complete switches in every category. It is important, also, to the petroleum industry because only diaphragms (not entire switches) need be carried by personnel doing field service.

Proof (test) pressures to 300 psi

The upper and lower sections of the diaphragm capsule are molded to fit the sensing element exactly. The top section prevents the diaphragm from stretching beyond normal curvature when surges above system pressure are encountered, and there is no possibility of metal distortion that would affect switch accuracy. In the low settings the new Barksdale pressure switches will actuate at 0.1" mercury with proof (test) pressure to 10 psi. In higher ranges they will go up to 300 psi proof (test) pressure at settings to 150 psi.

Stripped switch (single and dual control)

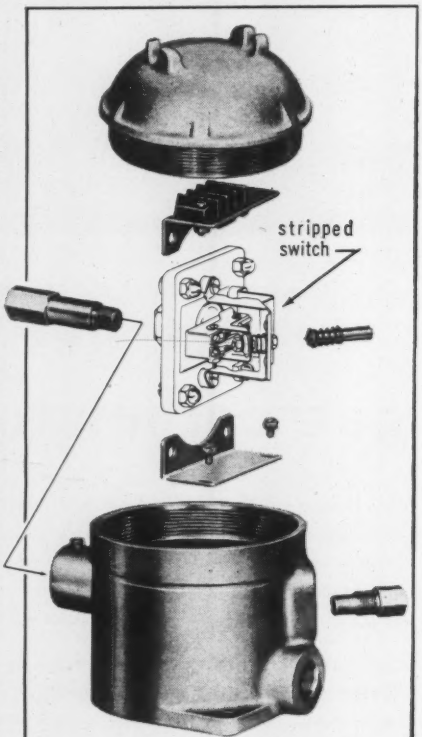
Addition of a switching element (No. 4 above) to the basic diaphragm unit makes a stripped switch for use in a common cabinet with other electrical devices. Original equipment manufacturers need not pay for unneeded housings. Extremely fine adjustment is possible because the adjusting screws have 64 threads to the inch. Adjustment may be made with a screwdriver or a wrench.

Housings added to suit

Addition of a sealed housing (standard, terminal block, or explosion proof) to a stripped switch completes a pressure switch that can be ordered "tailor made" for any desired application. In the standard housing, free wire leads are through a ½" nps conduit conductor. Wires are held firmly in place by a special tension clip that prevents disturbing the switch adjustment through careless wire handling. Terminal block housings are available for wiring convenience. Pottable electric outlets and external adjustment on explosion proof housings were suggested by the petroleum industry. Servicing instructions on all Barksdale switch housing are on the inside of a tamper proof cover to allow for painting of units.

Ask for new catalog

New Barksdale diaphragm pressure switches offer you something new in accuracy, proof (test) pressure, and economy. The just-printed catalog tells the complete story. Ask your Barksdale representative or write to Barksdale Valves, 5125 Alcoa Avenue, Los Angeles 58, California.



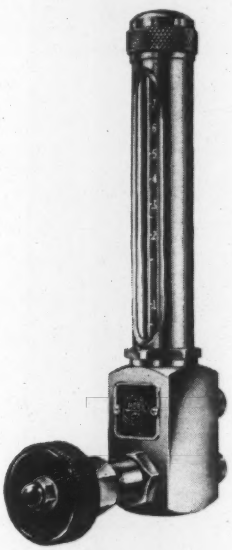
D1X (single setting) and D2X (dual control) explosion proof pressure switch. Pottable electric outlets. External adjustment.

CIRCLE 72 ON READER-SERVICE CARD

OK Flow Sheet 6

HOKE REPORTS ON FLUID CONTROL

MEASURING, METERING AND DO-IT-YOURSELF



FLOW WATCHING FOR FUN AND PROFIT

(Follow the bouncing ball)

After making flo-gages for longer than we'd like to remember, we've come to realize that there's no one simple answer to the problems of flow measurement. Rather than try to solve everyone's problems at once, we've concentrated our efforts in the low, but delicate, flow ranges.

The variable area principle (the ball float in tapered tube bit) is nothing new, and we haven't done much to advance science here. But what we have done is to build some direct reading flo-gages that provide pretty accurate pictures of the downstream activities of some of your favorite gases. Depending on the gas you're using, we've made units with maximum ranges from 0.7 liters per minute up to 44 cubic feet per hour, and we've even built a needle valve into one unit for fussy flow watchers.

Serious hydrodynamicists (flow watchers, to you) will be happy to hear that they can get Hoke flo-gages in straight, angle and panel mounting models.

For a guide to flow-watching, make your mark in the box on the right.

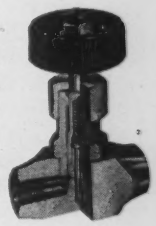
One good turn deserves another, and it takes twenty to move the stem of the Hoke 280 Series metering valve from the closed to the full open position — a total of 9/16". And in case you lose count (or can't count) we can supply it with a vernier handle that shows turns and fractions of turns for accurate re-set.

What you're moving when you twirl the wheel on this bar stock needle valve is really a needle. It has an 8° included angle and seats in either a .062 or .125 orifice, so you can see it's possible to turn down to a pretty accurate trickle. If an 8° included angle will still not give you the control you want, we've turned stems that read out to a 1° included angle.

Now, here's a real stopper—a Teflon seat. In this modification, the needle is spring-loaded so that it can't gall, or be scored. And it's backed by a Teflon seat for positive shut-off. This seat bottoms on a raised orifice in the valve body and can be used to hold pressures up to 3000 psi. Vacuum's a snap, too.

If these facts leave you still unmoved, we've got a few more gems to dazzle you with. For instance, you can use these valves to temperatures up to 450°F. And you can choose from brass or 316 stainless steel.

And if you're one of those people who must be different, why not build one yourself. It's easy and you can do it by reading our 280 Series Data Sheet. All you need is a screw machine, turret lathe, milling machine and a few other easily acquired gadgets. However, if things don't work out too well, you can still get them from us.



To be really knowledgeable in the field of fine metering, all you have to do is read the facts in the Data Sheet. A check in the 280 box will bring you instant information.

We're going West . . . and would like to see you at the Instrument-Automation Conference & Exhibit. We'll be at booth #723 with *all* our measuring & metering "devices" and perhaps even a little "do-it-yourself." See you there?

Hoke's Performance Guarantee—*Every Valve Leak-Tested!*

HOKE INCORPORATED
31 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ 280 Series Metering Valves
- ☐ Flo-gages
- ☐ '61 Product Parade
- ☐ Complete Catalog GC 960

NAME_____ TITLE_____

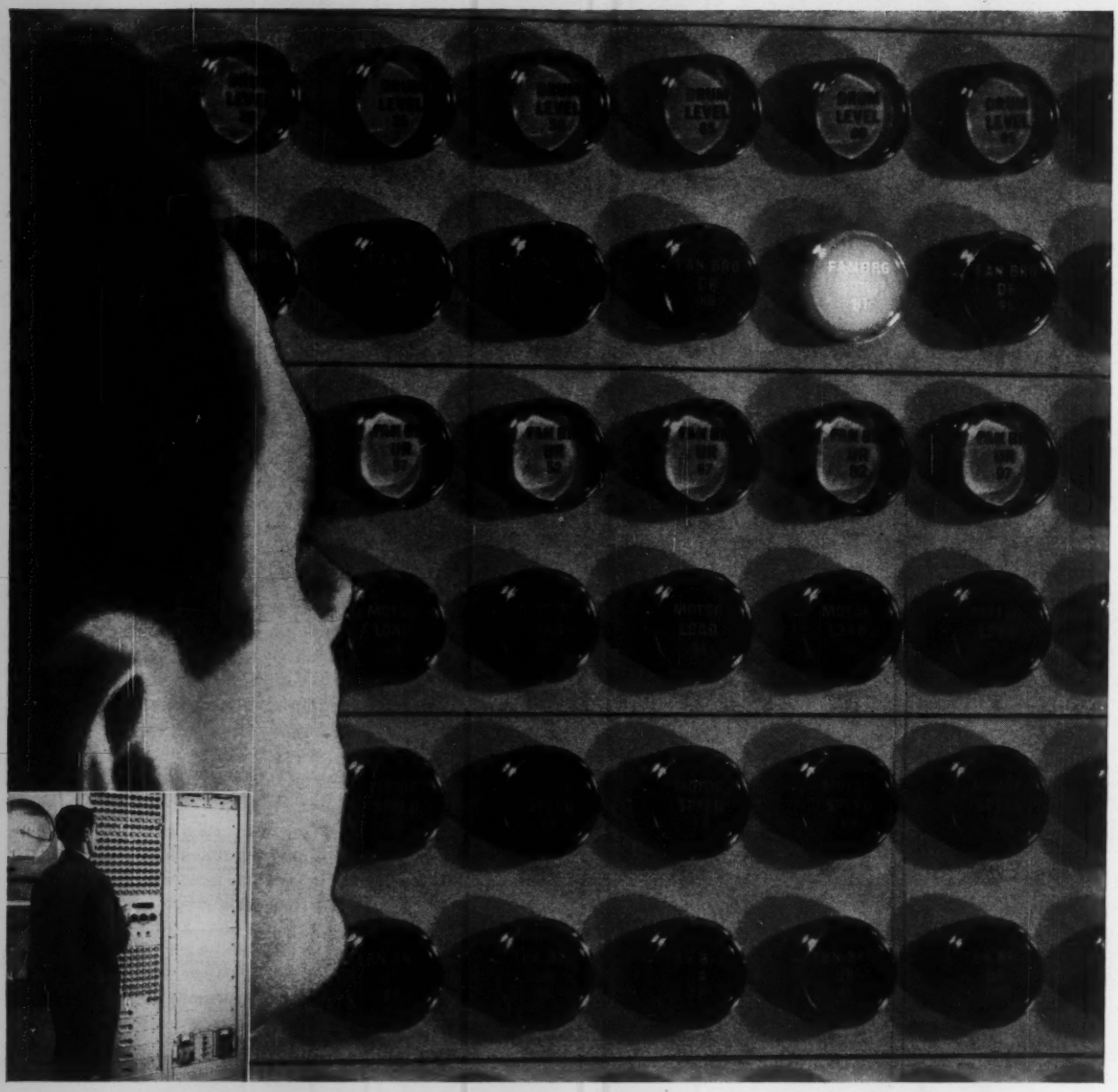
COMPANY_____

ADDRESS_____

CITY_____ STATE_____

SEE OUR CATALOG IN SWEETS PRODUCT DESIGN FILE

CIRCLE 73 ON READER-SERVICE CARD



DANGER! Out-of-limits

Just seconds ago a bearing temperature went out-of-limits . . . the Hagan AIM (Alarm Indicating Monitor) has energized the alarm light and sounded a warning horn . . . and, just seconds after the upset, the operator is ready to take corrective action.

Designed to protect valuable plant equipment, the Hagan AIM makes it possible for one man to monitor pressures, temperatures, flows, levels, closures from several critical areas at the same time. AIM can be set for either high or low alarm points, or both.

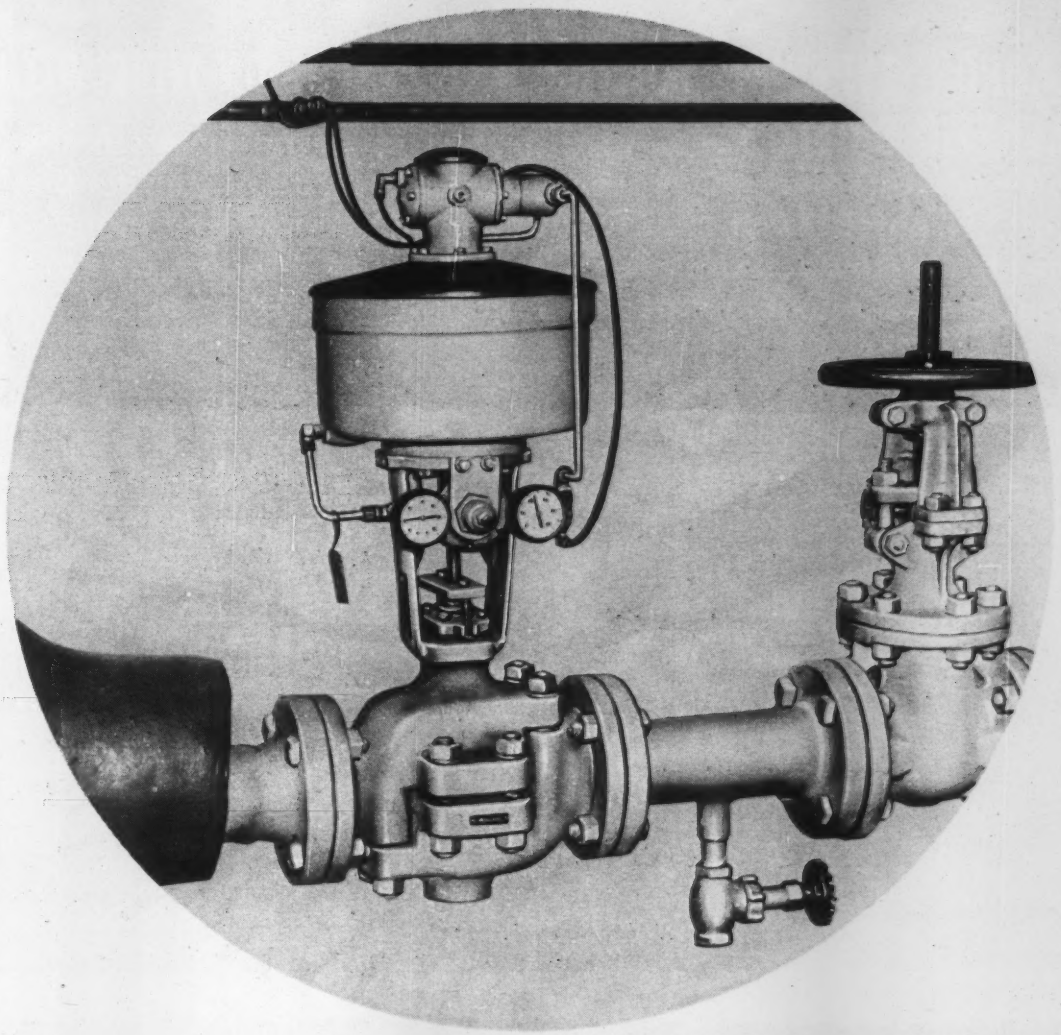
Combining all alarm functions in one instrument, the AIM will monitor *any* input which can be represented by DC voltages as low as 10 millivolts full scale, with an accuracy of ± 0.1% full scale. Providing maximum information on minimum panel space, the readout and alarm panel for 200 alarm points will fit into a 19" × 47¼" panel area.

For more information about the low-cost Hagan AIM, write or phone the address below.

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISIONS: CALGON CO. • HALL LABORATORIES • BRUNER CORP.

CIRCLE 74 ON READER-SERVICE CARD



A Split-body Valve is not a "Specialty"

...it is a practical, all-purpose control valve

The Conoflow Series LB valve shown is handling 100 psi steam. This is not unusual. Actually, the vast majority of the thousands of LB valves in service are handling water, steam and other common plant fluids. In fact, more than 80% of LB orders call for *standard* cast steel or ductile iron construction.

LB valves were selected because they give *better control, greater dependability* and *unequalled maintenance savings,* all at a *low initial cost.*

More and more users are standardizing on the LB valve right down the line because they know that LB valves mean *less downtime,* resulting in a more profitable plant operation.

Write for NEW Bulletin LB-4. Be convinced.

CONOFLOW SUBSIDIARY WALWORTH

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

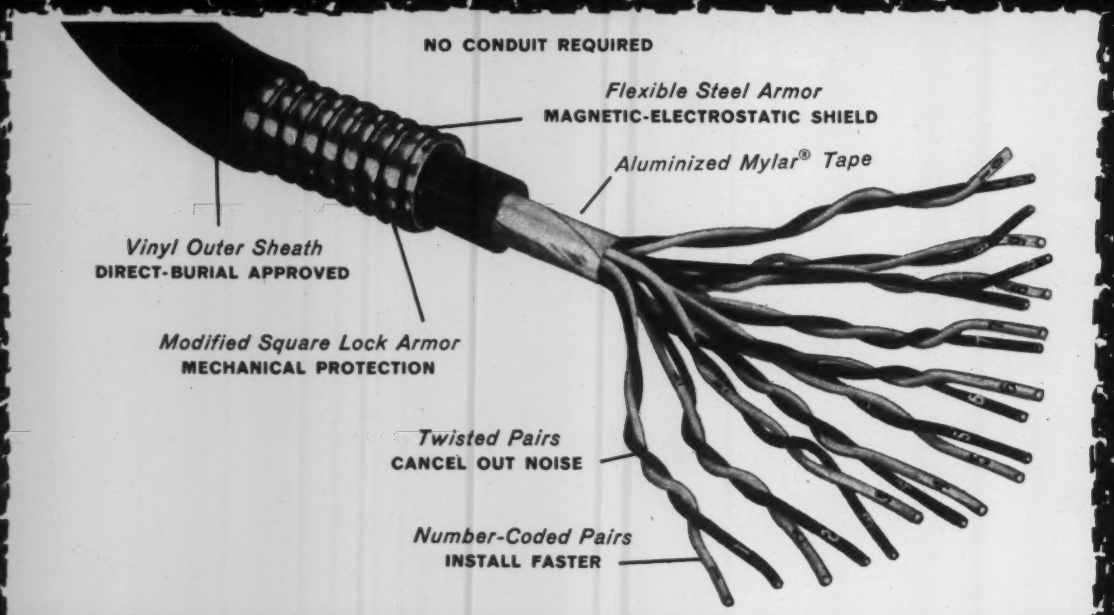
2100 ARCH STREET, PHILADELPHIA 3, PA.

CC110

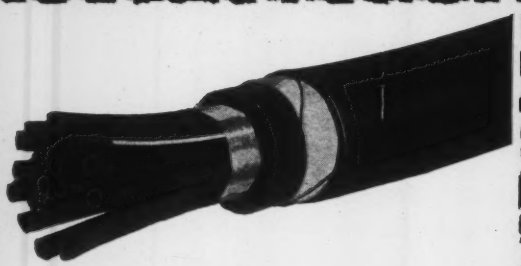
CIRCLE 75 ON READER-SERVICE CARD

DEKORON TYPE "AT" MULTICOUPLE EXTENSION WIRE WITH MAGNETIC SHIELD *keeps your process up to par years longer.*

Other advantages of Dekoron Type AT include easier installation . . . greater resistance to crushing, chemical and moisture attack for lowest maintenance. Always specify Dekoron products for maximum performance with minimized cost.



Dekoron New Metl-Cor combines exclusive parallel tubes of copper or aluminum with polyethylene protective sheath. Lack of "corkscrew effect" speeds installation. Dekoron also offers a full line of metal-armored tubing harnesses.



Dekoron Protecto-Pac (Type FB shown), an all-plastic harness with high resistance to weld splash, sparks, flash fires, etc. Dekoron Poly-Cor (not shown) has number-coded polyethylene tubes, Mylar® vapor barrier, flexible vinyl outer sheath.

Dekoron products

quality • research • service

SAMUEL MOORE & COMPANY • DEKORON PRODUCTS DIVISION • MANTUA, OHIO

The Temperature Control Powered by the

IRREPRESSIBLE FORCE OF MERCURY–

for Accuracy with Rugged Dependability

All Partlow temperature controls are directly and positively actuated by mercury, the metal in liquid form whose reaction to changes in temperature is as predictable as it is powerful.

Unlike delicate electronic controllers, the mercury-actuated Partlow requires no outside power source. No amplifiers. No finicky levers. And no "babying"! With a Partlow you can be sure of getting accurate, dependable control even under extreme conditions of shock and vibration.

Mercury-actuation makes possible maximum design efficiency and simplicity too. The Partlow has fewer parts to go wrong. And fewer service problems (with less "down" time) should trouble occur. You can replace the thermal element of any Partlow control instantly, right at the job site, without recalibrating, fitting or factory adjustment.

Whatever the process or application, you'll find a Partlow temperature control to fit it dependably, economically, *precisely*. Mail coupon today for full details.

PARTLOW

TEMPERATURE CONTROLS

World Export:
Ad. Auriema, Inc., 85 Broad Street, New York 4, N. Y.

THE PARTLOW CORP., Dept. D-861
NEW HARTFORD, N. Y.

Please send condensed Catalog of Partlow temperature controls and allied equipment for industrial heating and refrigeration.

Name and Title .....

Company .....

Address .....

City and State .....

.....

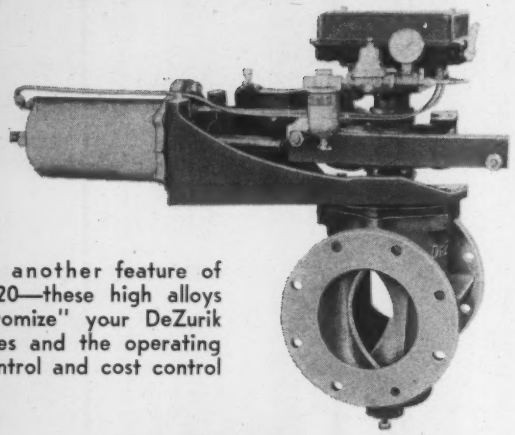
CIRCLE 77 ON READER-SERVICE CARD

← CIRCLE 76 ON READER-SERVICE CARD

CONTROL!

POSITIVE PRECISION FLOW CONTROL PLUS SUPERIOR CORROSION CONTROL WITH DeZURIK HIGH ALLOY CONTROL VALVES

AUTOMATIC FLOW CONTROL with almost unlimited flow characteristics . . . with highest rangeability, capacity, accuracy . . . with absolutely dead-tight shut-off and leakproof stem seal—that's the kind of complete CONTROL you get from every DeZurik Control Valve. Only these valves give you the original DeZurik Eccentric Action—friction-free, non-binding, positive positioning, unrestricted flow. And only these valves can be changed in throttling characteristic by simply changing a cam in the positioner. No dismantling, no shutdowns!



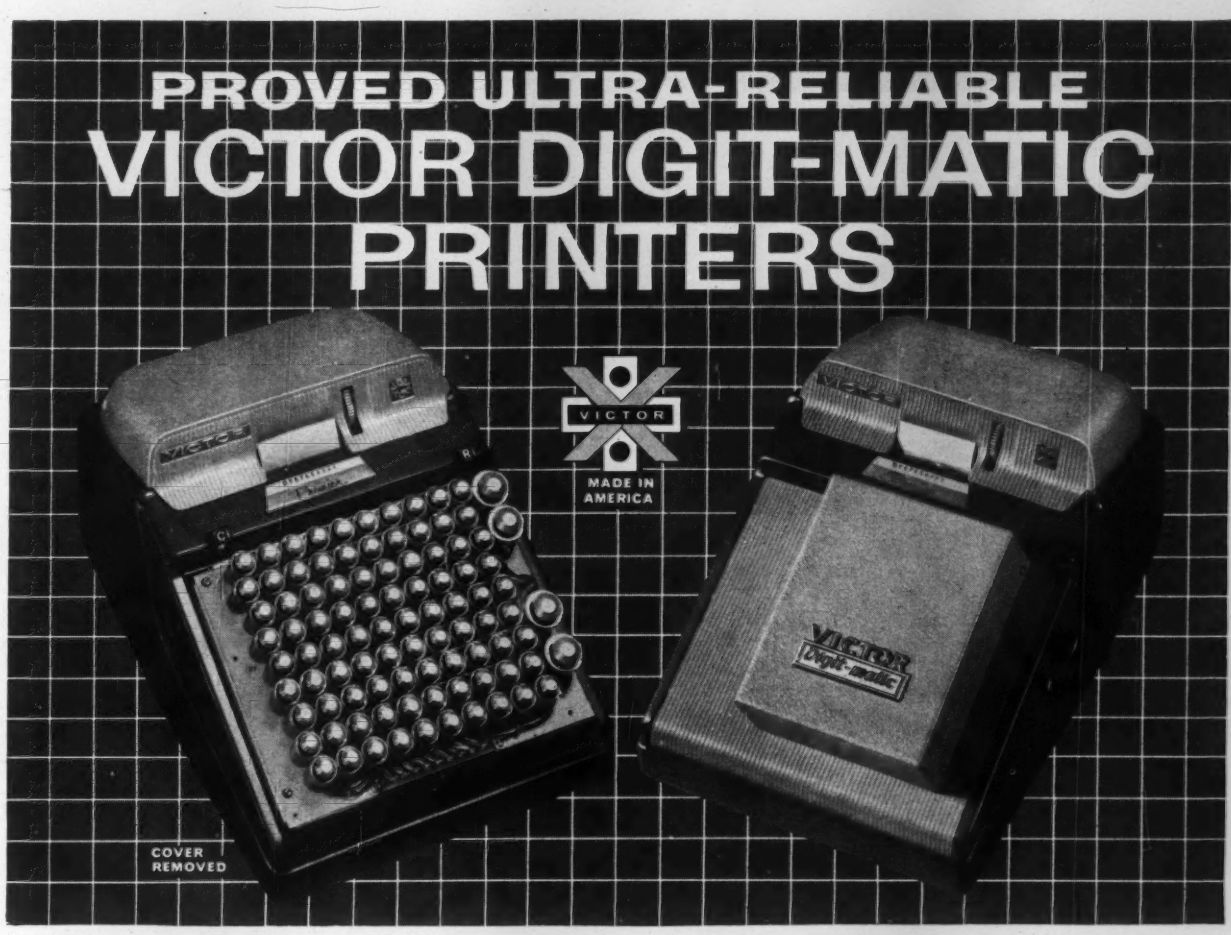
SUPERIOR CORROSION CONTROL on the toughest services is another feature of DeZurik Control Valves. Monel, Nickel, Hastelloy B or C, Alloy 20—these high alloys and many other resistant body-materials are available. You "customize" your DeZurik Control Valves with exactly the body and plug materials, the sizes and the operating units you require; you get precisely the flow control, corrosion control and cost control you've wanted!

Ask For Control Valve Bulletin 150

DeZURIK CORPORATION
SARTELL, MINNESOTA

CIRCLE 78 ON READER-SERVICE CARD

PROVED ULTRA-RELIABLE VICTOR DIGIT-MATIC PRINTERS



160,000,000 digit impressions without failure

Rugged, Trouble-Free—Digit-Matics are specially built to stand the strain of continuous operation. In a durability test, over 160 million digit impressions were made without breakdown or need of adjustment. The machine tested operated continuously, eight hours per day until 160 million digit impressions were made. During this period only normal lubrication and cleaning were performed.

Parallel or Serial Entry — Automatic and unattended, solenoid-activated Digit-Matics print out alpha-numeric data from remote equipment. High speed parallel entry models accept up to 10 digits at a time, print up to 4 lines per second. Serial entry models accept 1 digit at a time, up to 11 per line.

Two-Color Printing — Positive values in black, negative values in red. Ideal for "accept-reject" sequences, testing applications, accumulating data from two sources on one Digit-Matic, and many other uses.

Adaptable to Your Specific Needs — Line includes listers, accumulators and calculators. Versatile units can handle degrees, minutes, seconds, fractions. Other modifications: superimposed keyboard for manual use, time readings, counters, etc.

Immediate Field Service — 70 factory service branches and service representatives in over 600 cities assure uninterrupted operation. Victor offers 30-day delivery on most Digit-Matics. Mail coupon now for product data and application information.

VICTOR
ELECTRONICS DIVISION

Victor Adding Machine Co., Chicago 18, Illinois
Victor Adding Machine Co., (Canada) Ltd., Galt, Ont.

Manufacturers of Digit-Matic Printers, Scanning Printers, Electrical Keyboards, and Digit-Matic Data Punches

ICS-8

Victor Adding Machine Co.
Chicago 18, Illinois
Send full information on Victor Digit-Matics.

My application is_____

Name_____ Title_____

Company_____

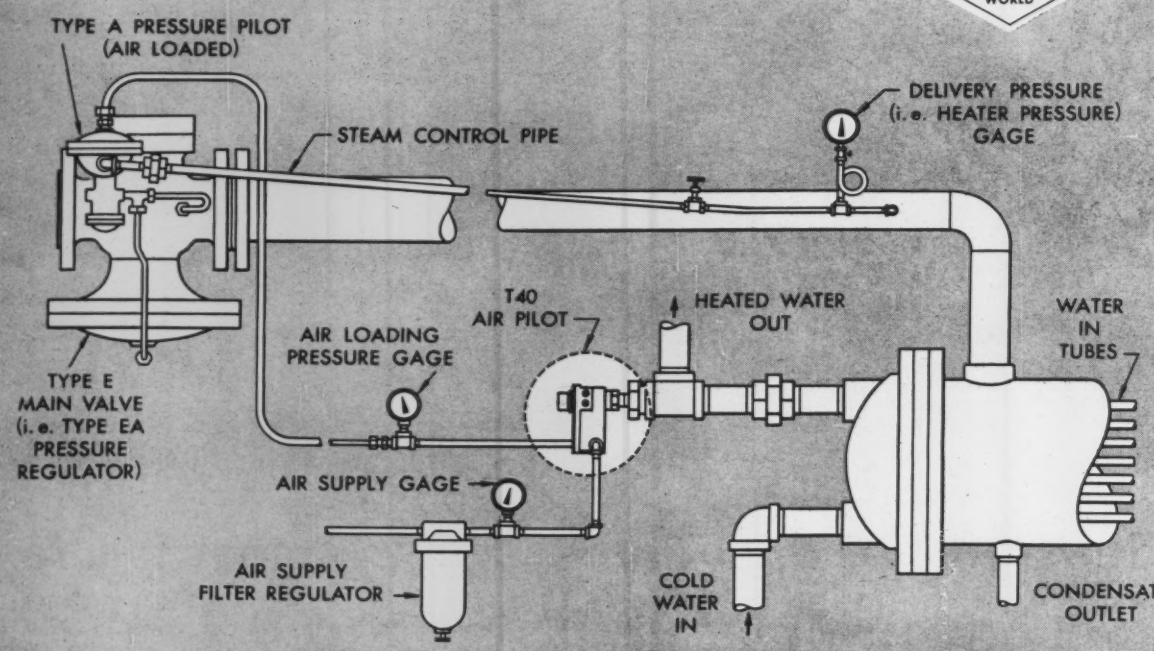
Address_____

City_____ State_____

CIRCLE 79 ON READER-SERVICE CARD

New Spence Temperature Control System with Cascade Control Accuracy at Regulator Costs

THE MOST COMPLETE LINE OF PRESSURE AND TEMPERATURE REGULATORS IN THE WORLD


TYPE A PRESSURE PILOT (AIR LOADED)
STEAM CONTROL PIPE
DELIVERY PRESSURE (i.e. HEATER PRESSURE) GAGE
T40 AIR PILOT
HEATED WATER OUT
WATER IN TUBES
AIR LOADING PRESSURE GAGE
TYPE E MAIN VALVE (i.e. TYPE EA PRESSURE REGULATOR)
AIR SUPPLY GAGE
AIR SUPPLY FILTER REGULATOR
COLD WATER IN
CONDENSATE OUTLET

TYPE EAT40 AIR-CONTROL TEMPERATURE REGULATOR (Patent Pending)

In a recent installation the new Spence air-control temperature regulating system provided:

- ±5°F control accuracy under wide and instantaneous load swings of 210 to 80 gallons per minute.
- Up to 50% reduction in cost as compared to instrument systems of similar accuracy.

This unique cascade-type control with throttling range adjustment independent of maximum heater pressure was developed to meet today's demand for greater control accuracy.

Additional features of the new Spence Temperature Control System include:

- 200°F wide adjustable temperature range
- Adjustable speed of steam pressure change
- Over and under temperature protection
- Pressure limit control
- Fast response
- Very low air consumption
- Field reversible for heating or cooling

The Spence Type EAT Air Control Temperature System, when properly installed, will tame wide ranging, fast changing loads of instantaneous heaters and modern heat exchangers. The cascade principle plus the use of an extremely fast responding bi-metal temperature sensing element reduce time lags and provide control stability.

Here's how the new Spence system operates:

Quick response is based on a bi-metal temperature sensing element.

Temperature pilot continuously regulates a loading air pressure.

This loading signal, when applied to a pressure regulator to reflect heater temperatures, causes it to adjust the main valve as changes in load require.

Spence has also developed a new pressure control system based on this same cascade principle. This system has a control accuracy of ½ psi or better from positive pressures through the vacuum range to 30" Hg.

For complete information on these new air controlled temperature and pressure control systems, write for your copy of Bulletin 9.

SPENCE ENGINEERING COMPANY, INC.
Walden 1, New York SE-148A

CIRCLE 80 ON READER-SERVICE CARD

HOW MUCH automation ...and WHEN?

BAILEY 700 SYSTEMS can help you make sure . . . with step-by-step benefits

Many important—and profitable—improvements in operations can be accomplished with analog and digital computer equipment.

Too much, too soon, however, can be costly—as can too little, too late. Intermediate stages of refinements in measurement and control are desirable and necessary. These not only can produce substantial benefits, but can demonstrate the additional improvements possible with further—or ultimately complete automation. Bailey step-by-step automation assures against loss of prior investment.

Bailey engineers can help you determine optimum usage of *Bailey 700 Analog and Digital Systems* in your operations. They are equipped, by broad experience, to provide single-source responsibility from sensing and measuring instrumentation to complete automation. *Bailey 700 Systems* are installed, in operation, or on order, at locations from coast to coast and throughout the world.

Find out what this Bailey experience can offer you. Contact your Bailey District Office.

SIX STEPS TO FULL AUTOMATION

Centralize and simplify information display—use analog and digital techniques to clarify information, aid operator understanding, improve reliability of interpretation, and save space.

Extend use of interlocks and limiting circuitry—use digital solid-state components to extend supervisory controls... minimize effects of human error.

Increase use of automatic sub-loops—simplify and standardize the starting, controlling, and stopping of major plant components and sub-systems.

Extend on-line controls—integrate sub-loops, interlocks, and limiting controls with conventional controls to secure automatic operation over full range, once unit is on the line.

Provide performance monitoring—add computing facilities to provide up-to-date calculations for operation improvement and maintenance scheduling.

Integrate all system elements—add start-stop control to provide full automation, the ultimate goal.

G139-1

INSTRUMENTS, CONTROLS AND SYSTEMS

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 81 ON READER-SERVICE CARD

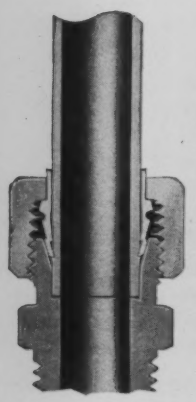
THESE PARKER TUBE FITTINGS MEET YOUR EXACT NEEDS

Instrumentation and processing call for specific fittings—not a "general" type

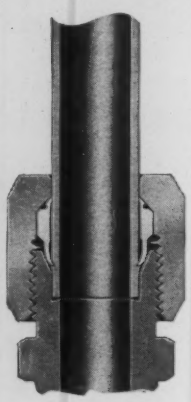
Parker covers *every* specific processing application with a fitting built for the job. There's inexpensive "Intru-lok" for instrument air . . . husky "Ferulok" for high pressures in steel and stainless steel. Both are positive, bite-type fittings. For complete corrosion resistance, new "Ridg-lok" is 100% of type 316 stainless.

Where flared tubing is used, the Parker 37° "Triple-lok" is the acknowledged leader, available in any practical metal.

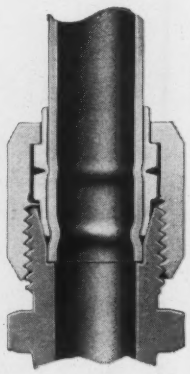
For extreme temperature conditions at any pressure, "Weld-lok" combines ease of assembly and streamlined flow. "Braze-lok" withstands somewhat less heat, but is even easier to assemble and can be disassembled when necessary.



FOR INSTRUMENT AIR, use "Intru-lok®" brass and aluminum tube fittings with the captive ferrule you can't lose. For copper, aluminum, Nylon and "Parker-POL" polyethylene tubing. Simple, compact, easy to install, inexpensive. Ask for Catalog No. 4324.

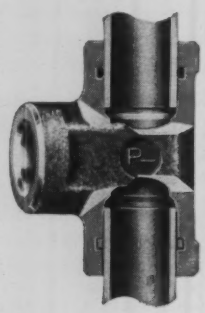


HIGH PRESSURES require "Ferulok®" heavy-duty flareless fittings with the visible bite that lets you make sure you have safe make-up. Usable with heavy-wall tubing. Excellent vibration resistance. Stocked in steel, stainless steel; available in Monel. Ask for Catalog No. 4320.

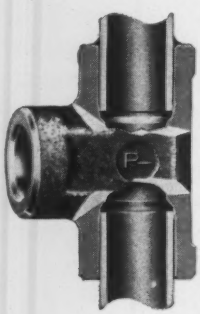


COMPLETELY CORROSION RESISTANT "Ridglok" fittings are all stainless steel (type 316). Unique ferrule design provides safe, dependable non-flare grip. Ferrule "foolproof"—identical ends make it impossible to put in backwards. Ask for Catalog No. 4322A.

BRAZED JOINTS can be used where there isn't room to swing a wrench. They give you a permanent joint, yet one that can be taken apart and re-used. You just apply heat, either to make or break the joint. Parker "Braze-lok®" is completely reliable for high pressures at temperatures up to 500° F. Steel, stainless steel, Monel and cupronickel. Catalog 4375.



WELD WITH Parker "Weld-lok®" whenever a permanent joint will best serve your purpose . . . when the process is hazardous, when temperatures or pressures are extreme, when vibration is a problem. "Weld-lok's" socket design makes assembly easy. Steel and stainless steel in stock; aluminum available. Catalog 4370.

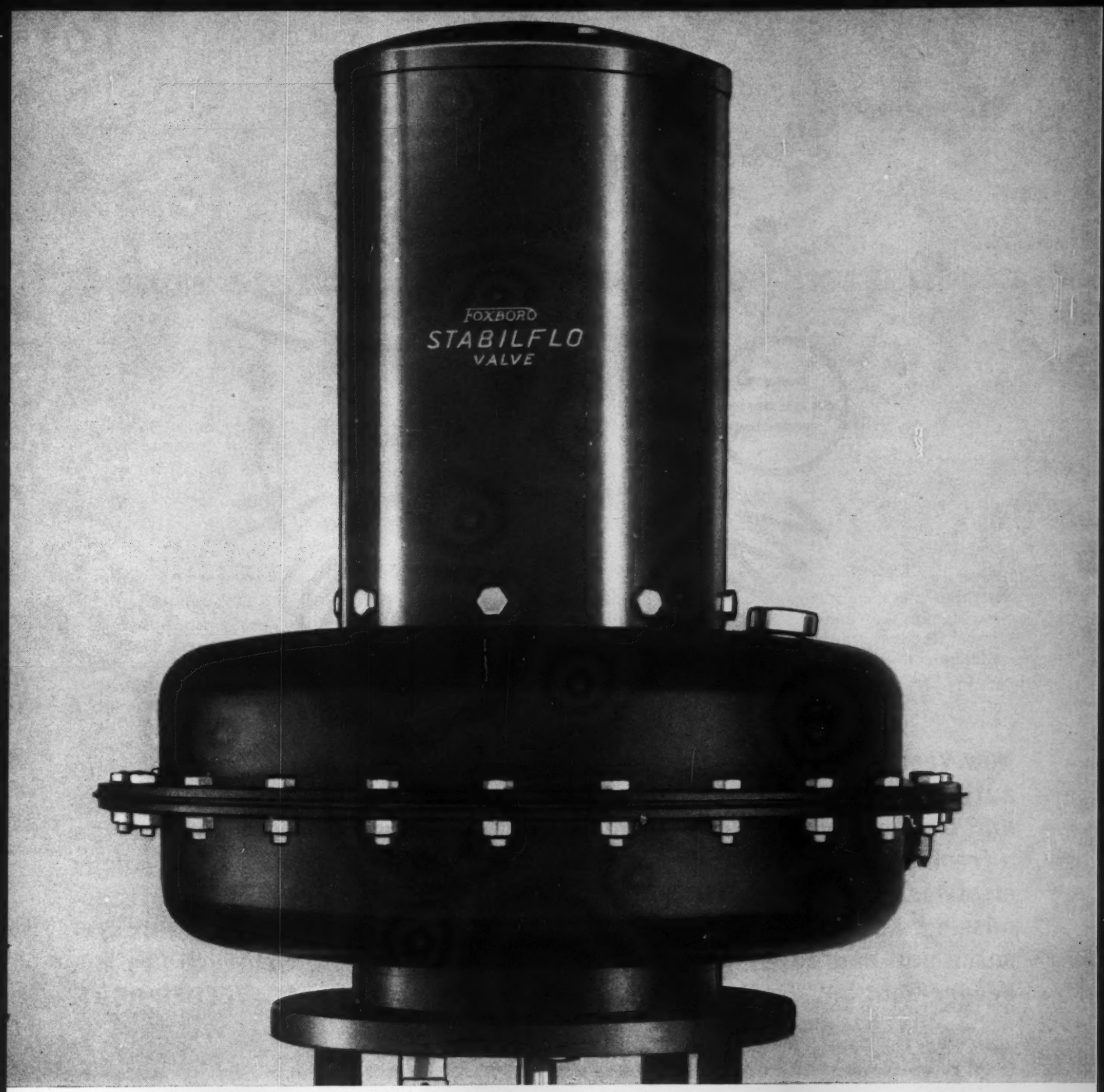


Complete specifications and engineering help are available from your nearby Parker distributor. Find him through the Yellow Pages, or write us direct.

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue • Cleveland 12, Ohio
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS
EUROPEAN DIVISION • PARKER-HANNIFIN N.V. • SCHIPHOL • THE NETHERLANDS

3200-PHd

CIRCLE 82 ON READER-SERVICE CARD

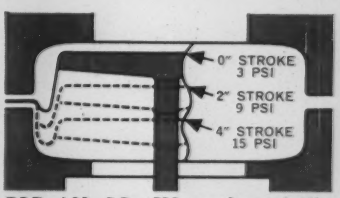


Now Foxboro gives you extra-high power plus long stroke...in one control valve motor

AT LAST — a "fail-safe," spring-opposed pneumatic valve motor designed specifically for larger size control valves. Butterfly, Saunders, Stabilflo* valves — the new Foxboro "160" motor is designed for them all. In most cases, it replaces expensive pneumatic cylinder operators and positioners.

1½ to 4-inch stroke — linear relationship between input signal and valve stem position . . . weatherproof construction . . . selection of air-to-lift or air-to-close action. You'll want to know more about this motor. Ask your nearby Foxboro Field Engineer for full details or write for Bulletin 5C-17. The Foxboro Company, 468 Norfolk St., Foxboro, Mass.

Reg. U. S. Pat. Off.

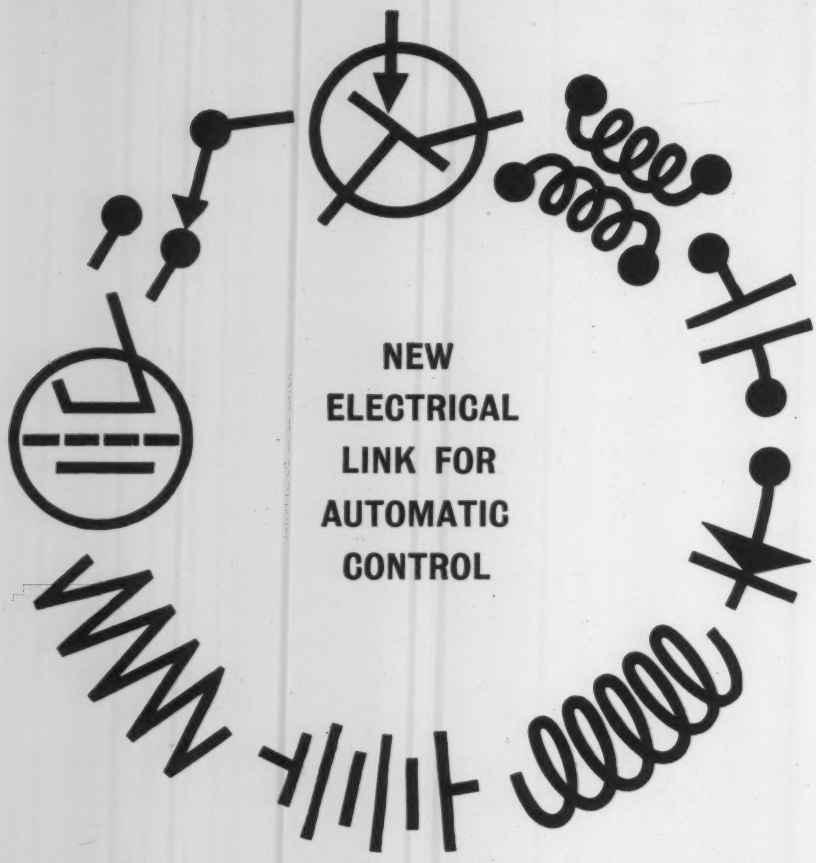


BIG 160 SQ. IN. preformed diaphragm maintains essentially constant effective area throughout the stroke. Result: a linear relationship between input signal and valve stem position — precise positioning of the stem for every signal change.

FOXBORO

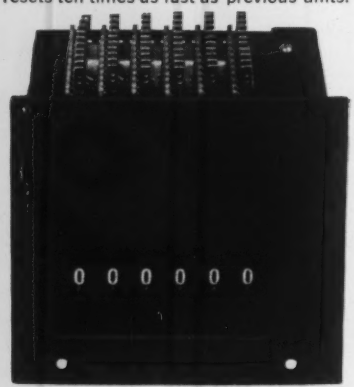
REG. U. S. PAT. OFF.

CIRCLE 83 ON READER-SERVICE CARD



New Veeder-Root high speed digital readout counter meets new needs in automation and system design. It's precision engineered to record, display and electrically transmit accumulated digital levels. More than that, it's a fresh approach to a widening range of automation needs . . . an ingenious electrical link for digital indication, data recording, storage and transmission, automatic sequencing, predetermining control. See what this versatile unit can do for your equipment or designs. Write Electrical Section, Veeder-Root Inc., Hartford 2, Connecticut. **count on . . . VEEDER-ROOT.**

Series 1744 High-Speed Digital Readout Counter saves time and labor by eliminating manual counting and recording of production. It counts twice as fast, resets ten times as fast as previous units.



CIRCLE 84 ON READER-SERVICE CARD

Ideas on the Undergraduate Curriculum

The role of abstract "models" (conceptual schemes, abstractions, constructs) in engineering should be buttressed by physical experience for optimum results.

GRANINO A. KORN
University of Arizona

ENGINEERING thought processes, as indeed all thought processes, do not tackle real physical phenomena directly. The complexity of actual physical situations calls for simplified descriptions in terms of verbal and symbolic models which abstract or symbolize properties of physical objects and operations.

Fig. 1 shows how the "extensional" or physical world of sense impressions is related to the "intentional" or abstract world of thought. An accurately defined abstract model is a mathematical model, usually introduced in terms of equations defining abstract relations between abstract objects.

An abstract model is a useful analogy for a physical situation if it is possible to establish rules of correspondence relating specific physical objects and relations to corresponding mathematical objects and relations. The scientific method constitutes a feedback process involving (1) induction and generalization of models abstracted from observation, (2) experimental and observational checks on these models, (3) renewed induction and generalization, etc. In the framework of engineering science, the essential criterion for adoption of a certain model is its usefulness in predicting experience and in permitting the construction of workable devices. In the framework of pure science, an additional important consideration is the ability of a model to suggest experiments resulting in new experiences. The most generally familiar mathematical models are the integral and real-number systems, and Euclidean geometry.

Models and Engineering Education

One educates technicians by teaching low-order abstractions, descriptive physics, and data on standards together with handbook-type formulas. As some of the models used in conventional electrical engineering are simple and exceedingly useful (e.g., d-c and a-c theory), this type of engineering education has gone a long way. The "new" engineering education is, however, supposed to prepare the engineer of tomorrow for an increasingly complex technology which will force him to cope with new situations far more frequently than his forebears had to.

It has been advocated to serve the new needs by teaching higher-order abstractions (abstract models of abstract models)—with the idea that these principles then could be brought to bear on a wide front of physical phenomena. The remarkable success of

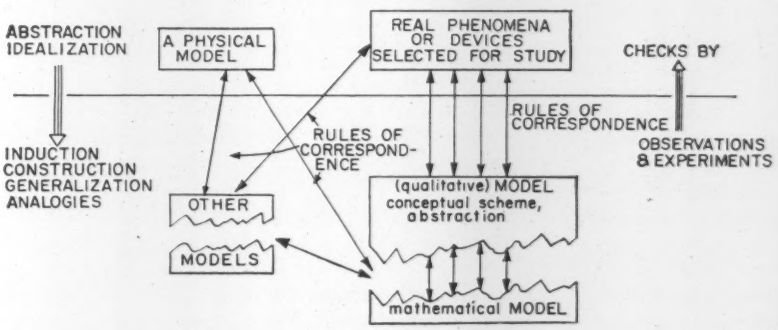


FIG. 1. PHYSICAL WORLD is related to abstract world of thought by rules of correspondence.

scientists occupying leading engineering positions in wartime has been quoted to support this view. While the writer is all for teaching first principles, they do not constitute a royal road to the solution of engineering problems. Another point, quite new in engineering education, should be stressed strongly:

a. Each student should be made aware of the nature of the thought processes indicated in Fig. 1. He must realize that the objects and relations considered in the abstract model are not identical with those in the real physical situation. This may seem obvious; but all too many confuse the abstract notions of "particle" or "inductance" with physical objects having physical properties. Such people may be frustrated when real systems do not perform like their idealized counterparts; more importantly, they do not realize the full freedom of action available in the construction of potentially useful abstract models.

The student and engineer should consciously realize what he is dealing with, either (1) real phenomena, (2) abstractions (e.g., field theory), or (3) higher-order abstractions (e.g., inductance as a circuit element). He must learn to distinguish clearly between abstract models and physical things and realize the idealizations involved in using the former, as well as the necessity to check abstract results against physical measurements.

The engineer should recognize abstract models as such and realize their advantages and limitations. The conscious use of abstract models, as contrasted to an unconscious search for "explanations" can free thought processes to encompass fields hitherto scarcely open to rational inquiry (operations research, game theory, models of economic systems, etc.).

b. The Instructor and Student should realize that an abstract model does not constitute an "explanation" giving reasons for physical occurrences. An abstract model is an autonomous construct or abstraction; we "understand" its "meaning" simply after running up and down the rules of correspondence which link the model to reality a sufficient number of times.

For this reason, various physical models and analogies between models (like that between oscillating circuits and mass-spring systems) are helpful to our "understanding." Such analogies, physical or mathematical, give our minds additional rules of correspondence to run up and down.

It appears that the human mind is so constructed that it positively enjoys such correspondences; thus "elegant" or "satisfying" physical theories involve many correspondences between physical and mathematical relationships. The finest physical theories are those which establish rules of correspondence to different, previously unrelated physical phenomena. In this lies both the usefulness and the aesthetic pleasure of using first principles in physics.

Models and the Engineering Curriculum

The undergraduate curriculum, of course, must introduce the most useful existing abstract models (theories) created by physicists and mathematicians. The teacher should indicate both the use of the model and its construction as a model. Not every engineer need be competent in constructing new models; that is the specific task of scientists and, in particular, of mathematicians. The engineer should, however know which books or experts to consult if the model needs to be changed, generalized, or improved.

Late-model electrical engineering curricula attempt to give each student a remarkably wide background in mathematics and physics during the first two years of the four-year course. After this, actual engineering subjects are developed in three course-sequences—circuit theory, electronics, and energy processing. These subjects then are brought to bear on the field of automatic control and various special electives are available to seniors. The author offers the following suggestions:

1. Courses in English, mathematics, and physics should stress strongly the theory of knowledge, namely, the nature of the model-thought process outlined in Fig. 1. It is important that engineers use models consciously, that they always know whether they are dealing with abstract or concrete relationships.

2. The modern electrical engineering curriculum provides a remarkable background in principles. The program appears, however, relatively weak in providing real knowledge or "feel"—the intuition or absorbed experience of actual simple physical situations. The student cannot "grasp" an abstract model in its proper context unless he has something to abstract from. Many students consider an "inductor" as either (1) an unseen item inside a decade box, or (2) a symbol in an abstract circuit model.

Theoretical courses should be preceded by a basic descriptive electrical (freshman) course similar to those given by the Armed Forces, with lots of simple d-c and a-c measurements, use of oscilloscopes with real circuit elements, etc. To build up motivation the students should build testers, meters, and oscilloscopes, which they can keep. It is also important to learn about commercially available components and their uses; a radio supply-house catalog might be a supplementary text-book.

3. After a course of this type the students would find that physical principles, circuit theory, etc., correlate with something they already know. The idea of finding something already known in each new course is a very important one for creating confidence. It is useful to encounter the same material in different courses at different levels of abstraction. Thus a descriptive-type course in electricity (low level of abstraction) followed by a course in atomic phenomena (engineering physics) and then by a course in circuit theory and field theory, would benefit all.

MR. WHITMER is a Government Contracts Administrator with Admiral Corporation where he is responsible for the corporate performance of contract requirements. He has been a Group Leader in the publication department of Admiral and a Technical Editor with Motorola, Inc.

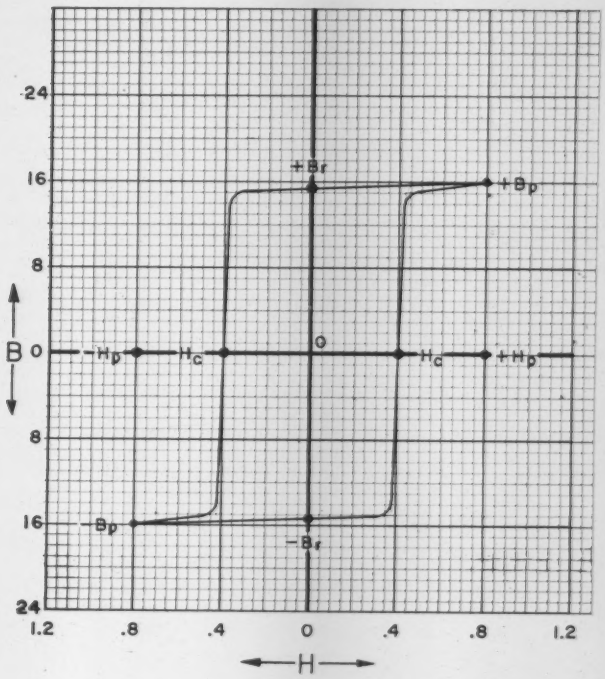


FIG. 1. CHARACTERISTICS of magnetic materials usually are described via the hysteresis loop showing flux (B) versus applied mmf field (H).

Magnetic Memory Cores

The magnet, with its bidirectional field, is admirably suited to binary-type information storage. Here is an introduction to magnetics, core properties, physical characteristics, test procedure and basic wiring.

MELVIN WHITMER

MAGNETISM is closely related to electricity, and magnetic properties can be defined by analogous electrical properties. The "current" in magnetics is *flux*, and the analogy is carried further by speaking of flux flow. The cgs unit of flux is the maxwell (Φ), defined as one line of flux. The "voltage" of magnetics is the *magnetomotive force* (H) usually expressed in ampere-turns. The cgs unit of this force is the gilbert (f), which is $5/2\pi$, or 0.794, ampere-turn. The "resistance" of magnetics is the reluctance offered by a vacuum to magnetic lines. This unit is called the *rel*. These basic magnetic units bear the same relationship as that of Ohm's law:

$$\Phi = f/rel;\ I = E/R$$

One maxwell (flux line) per square centimeter is one gauss (B); one gilbert (mmf) acting through one centimeter is one oersted (H); and the reciprocal of one rel per cubic centimeter is a permeability (μ) of one. These units bear the following relation to each other:

$$B = \mu H$$

A magnet can be "charged" to retain its field flux. In magnetism, the electron orbits of atoms are polarized so that the magnetic field created by each moving electron adds to form a total field within the material. (The electric counterpart is evidenced in superconductivity.)

The charge is placed in a magnet by induction from another magnet or from a d-c coil. When the applied force (field H) creates a field density in excess of the magnet capabilities, the magnet is said to be *saturated*. Removing the external force will result in

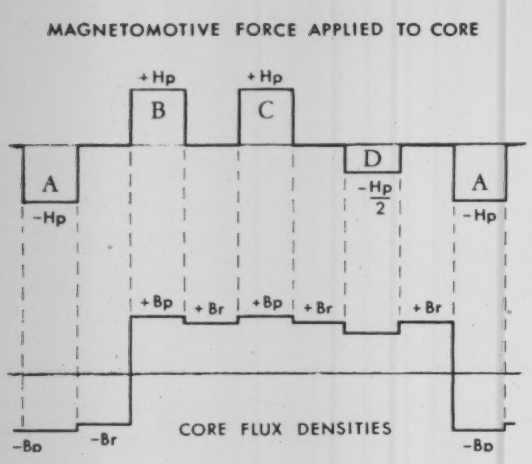


FIG. 2. TYPICAL SEQUENCE of test pulses, showing mmf applied to core at top, and resulting core flux densities (below).

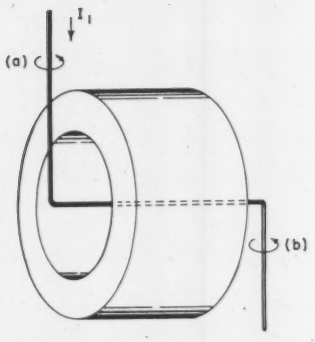


FIG. 3. CORE with wire threading its hole. Current shown will induce counterclockwise flux in core.

a reduction of flux density in the magnet to that of its remanence value (B_r).

The magnetic characteristics most desirable for a *permanent magnet* are (1) high permeability, (2) high coercivity (requires a large power input for magnetization), and (3) high remanence value.

Transformer cores require (1) high permeability, (2) low coercive force, and (3) low remanence.

Properties of a Memory Core

The magnetic-memory core must have slightly different properties from either the permanent magnet or transformer core. High permeability is still required, but moderate coercivity and high remanence field (B_r) are preferred. The memory core must not be influenced by stray magnetic fields; however, the polarity of the field must be reversible by pulse values readily available in a computer. The memory core must retain a large field because the purpose of the core is to generate an output pulse during a polarity reversal of the field, and the larger the field the larger the output.

The action in magnetic materials is easily shown with the hysteresis loop showing flux density (B) versus force field (H). The graph in Fig. 1 is of a core made of Deltamax. The vertical axis (flux density B) and the horizontal axis (designated H for magnetomotive force) are common to all magnetic loop graphs.

B_r shows the residual magnetism which remains after the application and removal of an external field. H_p represents the magnitude of the external magnetic field required to cause the flux to reverse direction. H_c represents the force required to demagnetize the material from a B_r position. These points identify the coercive force of the material. Note that the top and bottom portions of the loop do not run parallel to the H axis. This slope is the result of the permeability of air.

The magnetomotive force H_p creates a magnetic field in excess of the material capabilities. The flux B_p is the result of both the field in the material and the field around the material. When the applied force is removed, the field "slides" down the loop to the zero-H axis. This is the remanence value of the magnetic flux (B_r). The magnetomotive force $-H_p$ will set the flux at the $-B_r$ value, and the magnetomotive force $+H_p$ will set the flux at the B_r value.

An ideal hysteresis loop would be rectangular—that is, B_p would equal B_r. As a perfectly square hysteresis loop is impossible, the degree of squareness serves as a figure of merit.

The energy stored in a magnetic material is usable for developing an output pulse when the core flux changes polarity. The greater the flux density, the greater the output pulse. Designers would like to obtain a large output pulse with small applied force. This of course has definite limitations, but there are several alloys in addition to Deltamax which exhibit these qualities to a high degree.

Testing Cores

Magnetic materials are tested for operational characteristics by applying pulses to a circular core composed of the material under test.

Fig. 2 shows a typical sequence of test pulses applied to a core. Two monostable multivibrators provide pulses of H_p and ½ H_p magnitude. Pulse A sets the core in the $-B_r$ direction, which is generally called the ZERO direction. Pulse B reverses the flux, driving it to the $+B_p$ level, or ONE direction. Pulse C is of the same polarity as B and, therefore, can only drive the flux density to saturation ($+B_p$). A half-amplitude pulse (D) is applied to determine the amplitude of the induced voltage when the flux is momentarily reduced. Finally, the pulse A is applied to change flux direction and measure the output pulse.

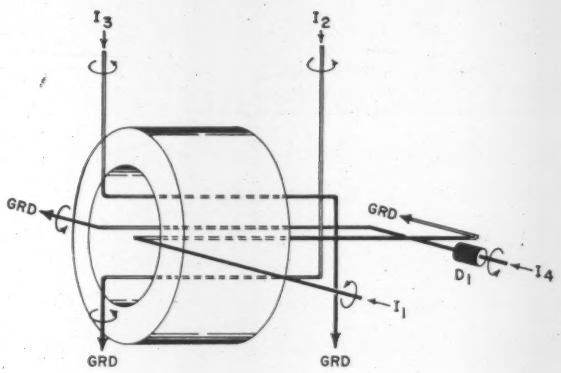


FIG. 4. CORE WIRING includes information wire (I_1), set wire (I_2), timing wire (I_3), and readout wire (I_4).

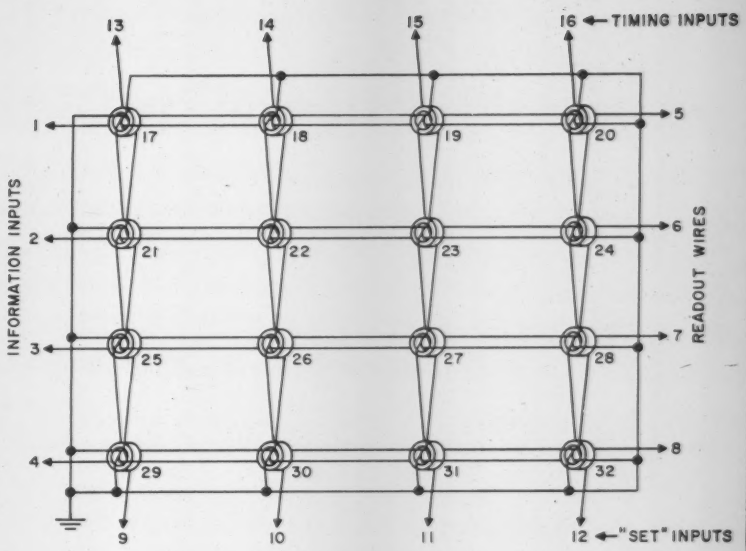


FIG. 5. TYPICAL CORE memory has hundreds of cores.

Physical Characteristics

A memory core usually comprises a doughnut-shaped plastic spool with a thin strip of metal wound on the spool (Fig. 3). Typical dimensions are:

Inside diameter	0.25 "
Outside diameter	0.375"
Width	0.198"

The cores are produced by rolling high-permeability metals into strips only 0.0005" in thickness and 0.18" in width, then winding the strips on the spools of plastic until a desired amount of metal is acquired.

With small cores it is not practical to use multiple-turn windings; the wires are simply threaded through the hole of the core. Current through the wire then produces a magnetic field which actuates the core. In Fig. 3 a current in the direction shown by I_1 will generate a field which will set the core flux in the counterclockwise direction.

Core Operation

A complete core wiring is shown in Fig. 4; wire size may vary from number 30 to 40. Arrows identify the current direction. The pulses are applied in this sequence:

I_2 sets the core in the ZERO state, which is the clockwise direction.

I_3 is the timing pulse which supplies ½ of the power necessary to change flux direction.

I_1 is the information pulse to be stored.

I_4 is the readout wire which will receive an induced pulse each time the flux is reversed.

The diode D_1 is included to block the induced readout pulse when the flux is changed from ZERO to ONE; D_1 passes the induced pulse when the flux is changed from ONE to ZERO.

The current pulse I_2 sets the core in the ZERO state before applying the input pulse. I_1 and I_3 must occur simultaneously to change the flux to the ONE state. The core will remain in this state regardless of single ½-H_p pulses (which may be applied to either the I_1 or I_3 wires). When readout is desired, a full H_p pulse applied to the I_2 wire will change the core from ONE to ZERO, and induce a pulse in the I_4 wire, which pulse will pass through the diode.

Memory Rack

As a complete memory may consist of several hundred cores, a method of affecting only one core at a time is required. Cores are selected by applying small pulses through two intersecting wires which both pass through only one core. A simplified version of a memory is shown in Fig. 5. Note that there are four *input wires* at left, four *timing wires* at top, four *readout wires* at right, and four *"set" wires* at the bottom. The input wires are pulsed by the information which is to be stored, while the timing wires are pulsed in sequence, from No. 13 to No. 16, by a pulse-generating "clock" multivibrator. The "set" wires are pulsed at the beginning and end of the storage time by the clock sequence. In Fig. 5, with a pulse applied to input number 3, and the timing pulse applied to number 14, the only core which receives both pulses will be number 26, which contains both number 3 and number 14 wires. All other cores will receive a ½-amplitude pulse, or none at all. Cores 18, 22, 25, 27, 28, and 30 still can be used without disturbing number 26. When readout is desired, the timing pulses are switched to the "set" wires and amplified to full H_p size. As these pulses are applied in sequence, the cores which have been actuated to the one state will reverse, thereby generating a pulse in the readout wire. The "set" pulse also assures that each core is now in the ZERO state, ready to receive and store more information.

In a complete memory, each core is assigned a letter or number to correspond to the information to be stored. Several thousand cores usually are suspended by the wires threaded through them.

Problems in Digital Recording

How to find and avoid errors in recording digital signals on magnetic tape

L. A. ORMORD
Epsco, Incorporated

DIGITAL RECORDING on magnetic tape requires driving the tape into saturation. This is usually discussed in terms of *ampere turns of write current* compared to *playback voltage*. It can be seen in Fig. 1 that overdriving to excess (200%) can cause more degradation in the playback signal than under-saturation.

The rate-of-change of head current during writing, as related to both tape velocity and head gap, should be such that the rise time is less than the time required for the tape to traverse approximately 30% of the head gap.

Many errors can come to light when a magnetic tape is read. The techniques for establishing their exact cause(s) are relatively simple, but time-consuming. The types of non-electronic digital recording errors can be categorized into three major groups: (1) Amplitude errors, (2) skew errors, and (3) distortion. Factors contributing to each type of error are as follows:

1. AMPLITUDE ERRORS
   a. Head-sensitivity errors
   b. Improper tape tracking
   c. Unsaturated tape
2. SKEW ERRORS
   a. Improper tape tracking
   b. Write head skewed
   c. Read head skewed
   d. Tape permanently damaged
3. DISTORTION
   a. Improper tape tracking
   b. Write and read head crosstalk
   c. Packing density distortion

Amplitude Errors due to Head-Sensitivity

To determine if signal degradation is caused by improper head sensitivity, compare the present sensitivity with the original sensitivity at the time of shipment from the manufacturer. If degradation exists on only a single track, reverse the tape end-for-end to place a different tape track over the same read head. This determines whether the head-sensitivity error is caused in the reading or writing process. If degradation continues to exist on the same read *head* after the tape has been reversed, the fault lies in the read process; but if the fault shifts to another read head (i. e., to the one now reading the improperly written track), the sensitivity error is in the writing process. (Obviously, this technique cannot be employed on a center track.)

Amplitude Errors due to Improper Tape Tracking

Improper tape tracking can cause amplitude errors and also contribute a skew error. Signal reduction can be caused by the tape track not being centered to the read head (i. e., improper tape registration). This can be observed by physically moving the tape in a lateral direction during readback while observing the head output on an oscilloscope. If the displacement in either direction produces a signal reduction, the tape was originally in proper lateral alignment. (Note *Skew* errors produced by moving the tape laterally are common and should be of no concern.)

To measure the magnitude of the tape tracking error, a tape should be recorded in the normal manner and the tracks made visible by the application of a magnetic viewing material (such as "Magna-See"). Physical measurements of the absolute track positions can be made and the magnitude of the misalignment determined. Note that tracking errors of one to two mils will not affect operation because the write heads record a broader track than is reproduced by the read heads.

Do not reuse any tape after applying these magnetic viewing materials.

Amplitude Errors due to Unsaturated Tape

If the tape is being saturated properly, a decrease in write current of 10% to 20% should produce no detectable reduction of the playback voltage at the read head output. This can be tested by placing a resistor in series with the write head. If the output signal drops proportionally to the reduction of write current, the tape has not been saturated properly.[3]

Skew Errors

Skew error (time difference between readout pulses from different tracks) is due to the manner in which the tape is moved across the heads. Contributing factors are:

1. *Gap tilt,* which is the angle between a line perpendicular to tape motion and the best straight line drawn through the center of the head gaps (Fig. 2).

2. *Gap scatter,* which is the deviation from the best straight line drawn through the center of the head gaps.

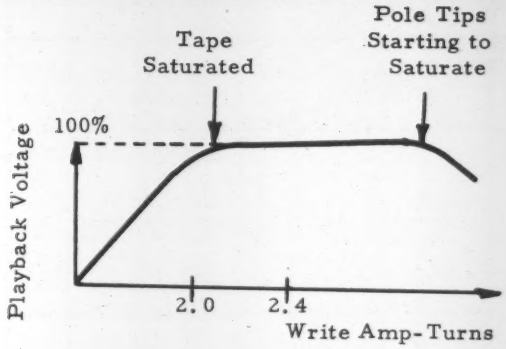


FIG. 1. Effect of tape saturation.

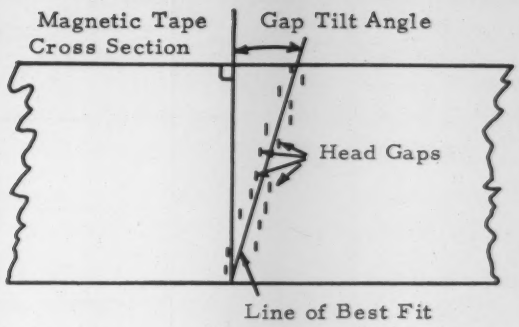


FIG. 2. Gap tilt skew error.

3. *Head base,* the positioning of the head in relation to the plane of tape travel (but not including the factors of gap tilt and gap scatter).

4. *Tape guiding errors*—errors due to stationary and rolling guides not being perpendicular to the direction of motion.

5. *Dynamic errors resulting from dynamic vibrations* in the magnetic tape base material, tape wow and flutter, and the total of all other minor contributions that cannot be defined separately.

Manufacturers of digital transports usually quote values for these quantities in relation to tape velocity. An important factor omitted from their specifications is the effect on the tape by the mechanisms which move the tape over the heads. It is the opinion of the writer, based on experience, that no manufacturer of digital transports provides, at present, a clear-cut mechanical procedure for aligning his drive mechanisms in the field. Therefore, an electronic check of time displacement error should be made after even the most minor readjustment of the tape-handler's mechanisms.

Write and Read Skew Errors

To separate write skew from read skew, the tape can be read on the write head with the tape traveling in the same direction in which it was recorded, but with the oxide side of the tape away from the head so that the head is reading the "printthrough." Any errors detected will have been contributed by the writing process.

When *tape packing density* is increased beyond 450 bits per inch, gap-width errors are of such magnitude that their contribution to skew also must be considered. During the writing process the trailing edge of the write-head gap controls the apparent bit position on tape. In reading, it is the center of the read-head gap which reproduces the apparent bit position. Once the writing process has been checked out, all other errors are in reading—or else the tape is damaged.

Typical values for skew encountered in the field are as follows, in microseconds (these are normalized for adjacent tracks 0.025" wide and 0.0625" center-to-center at one-inch-per-second tape velocity; the figures are for 1.5-mil Mylar tape):

Gap Tilt	—34.7 μsec	Tape Guiding	—25.0 μsec
Gap Scatter	—12.5 μsec	Dynamic	—75.0 μsec
Head Base	—33.4 μsec		

Skew Calculations

The maximum time displacement between outside tracks is defined by the formula:

$$T = (X/V)(N/2)$$

where T is maximum time displacement between outside tracks (in microseconds); X is skew variable being measured (in microseconds/inch/second); V is tape velocity (in inches/sec); N is number of tape tracks.

Example: The dynamic error for 16-track, 1" tape at a speed of 75 ips is:

$$T = (75.0/75)(16/2) = 8\ \mu\text{sec.}$$

Mechanical Distortion

Tension of 20 to 30 pounds will stretch 1" 1.5-mil Mylar tape about 5%. It is not unusual for tape mechanisms to run at a tape tension of 1 to 10 pounds per inch of width. If this tape driving force is applied unequally, damage can result. The effect may not show up immediately but can appear in time in the form of one edge of the tape being wavy.

Cross Talk

Common wiring on head returns should be avoided or, if this is not possible, careful calculations should be made to determine the effect of common currents in the write circuitry, and of common ground loops in the read circuitry.

Packing Density Distortion

Assuming that the magnetic-tape characteristics are not the limiting factor, signal degradation can be observed either in the form of improper writing or reading when bit packing density is increased. Usually this is affected by the head gap width and the time constant of the head windings. The read and write circuitry can counter to some degree the degradation resulting from the time-constant effects, but there are practical limits. As bit packing density is increased (with the characteristics of the magnetic tape, the write-read head, and of the electronic circuitry held constant), the threshold level—i.e., the 0-1 decision level—will be increased proportionally, thereby increasing the percentage of dropouts.

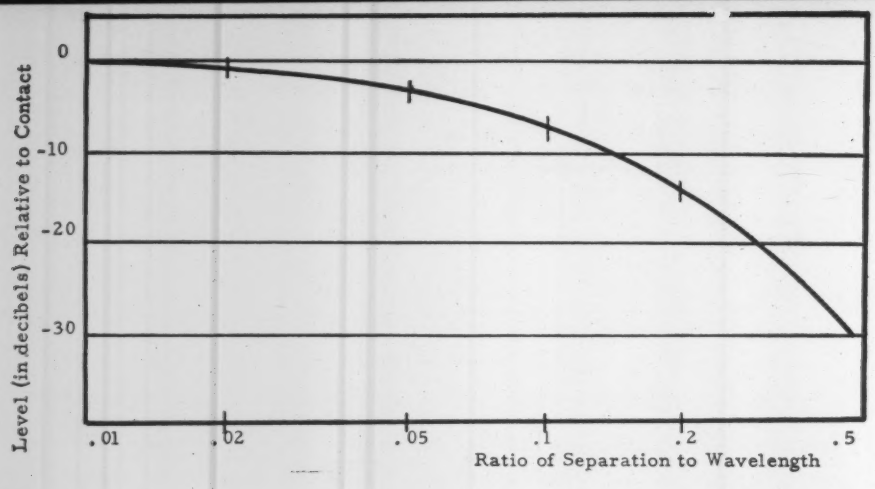


FIG. 3. Attenuation due to poor head-tape contact.

Signal Dropouts

Another common problem in digital recording is the dropout.* A dropout is defined generally as a 30% signal reduction; it is most frequently caused by poor head-to-tape contact. This poor contact may be due to improper handling of the tape or to unclean heads on the recorder (which leads to contamination of the oxide surface of the tape). It also can be caused by the distortion of the base material of the tape, or by a combination of all the factors.

The attenuation of a sinusoidal signal resulting from poor contact between tape and head is most pronounced in the shorter recorded wavelengths. This effect in playback is defined by the formula:

$$\text{Drop in playback level (in db)} = 54\ d/\lambda$$

where d is separation of tape from head, and λ is recorded wavelength on the tape.

Fig. 3 shows attenuation plotted against the *ratio* of separation to wavelength. This curve is universally applicable for any speed, frequency, and separation. Note that Fig. 3 illustrates the loss in signal level in playback only, assuming that the signal has been recorded perfectly. An equal or greater effect may be present in recording.

In playing a low-frequency signal of 15-mil wavelength, a separation of 1 or 2 mils affects the level only slightly. With a high-frequency signal (say, 1-mil wavelength), even a half-mil spacing results in a drop of more than 20 db. In digital recording, a 6-db (50%) drop in signal is considered critical. With a 1-mil wavelength, this takes place at 111 microinches (0.111 mil) tape-to-head separation. Since a dust particle might easily approach this size, the importance of clean operation cannot be overemphasized.

Although the majority of dropouts in digital recording are caused by dust and other contaminants lifting the tape away from the head, the next most significant causes are dents and creases in the base material. Dents can be caused either by foreign particles being wound up in the roll, or by roughness in the surface of the hub on which the tape is wound. These can cause a permanent set in many layers as the tape passes over the head. Stresses in the roll sufficient to stretch the backing 5% will generally leave a permanent impression. Stresses below the 5% point are not normally permanent. Creases usually are caused in handling (i.e., threading, making splices, removing the tape from the guides, etc.) or by damage to the edges of the tape because of uneven winding.

Most causes of distortion of the base material can be eliminated by using precision reels. The flanges should be closely spaced to minimize scattering of turns during winding, and the proper flange design will give greatly increased protection against crushing of the tape edges. The hub should not have threading slots.

If you have difficulty with signal dropouts arising from dust, carefully wipe the surface and backing of the tape with a lint-free cloth, such as a soft chamois, before and after using. To get rid of contamination that does not brush off easily, use a cloth lightly moistened with *Freon TF**. Aliphatic hydrocarbon-type solvents (heotane, gasoline, naptha, etc) also can be used. Warning! These solvents are flammable. *Freon TF* is non-toxic and non-flammable. Do *not* use carbon tetrachloride, ethyl-alcohol, trichorethylene, or unknown cleaning agents because they may soften the oxide, deform the backing, or both.

Storing and Handling

HANDLING

When tape is handled, the operator's hands should be clean to prevent contamination of the tape by body oils and salts, which will pick up foreign particles. Some operators find it helpful to wear clean white gloves to prevent contamination when handling tape.

Heads and guides of the machine should be cleaned each time a tape is placed on the recorder. The machine manufacturer's recommended cleaning procedure should be followed.

STORING

When finished using, tapes should be placed on a precision reel for uniform winding at moderate tension and then given protected storage. Recommended take-up tension for most recorders is four

* Based on articles published by Minnesota Mining & Mfg. Co.[4] The author has changed certain data to reflect Epsco's design pholosophy and takes full responsibility for this revised version.

* *Freon TF*, a du Pont product available from the J. B. Moore Corporation, Nutley, N. J.

to five ounces for each ¼" of tape width. The best method of protected storage is to place the reel in a self-sealing plastic case and to store it on end in a storage bin equipped with partitions between each reel. The plastic case protects tape from dust and sharp humidity and temperature changes. It also guards both tape and reel against handling damage when being transported between storage and work areas. Rewinding the tape once or twice a year during storage is recommended because this releases expansion-contraction stresses and lessens the possibility of blocking. This is particularly important for acetate-base tapes.

Extremes of temperature and humidity should be avoided. In general, recommended storage conditions for acetate- and polyester-base tapes are: 40% to 60% R. H.; 60° to 80°F.

If temperature extremes are encountered during storage or transit, tape should be brought to equilibrium before it is used. If a tape has been in storage or transit at sub-zero temperatures, it should be stored a minimum of four to eight hours at room temperature before it is used. Actually, it will not regain complete temperature equilibrium for 16 hours. This time can be shortened by accelerating temperatures, but these temperatures should not be over 100°F; otherwise condensation will form on the tape. Avoid using direct heat, such as lamps or other spot heat, to "warm up" a tape.

Effects of Excessive Temperature

In general, magnetic tapes will not ignite until they reach a flame temperature between 500°F (cellulose acetate) and 700° F (polyester), or a self-ignition temperature between 700°F (cellulose acetate) and 1000° F (polyester). At these temperatures, an ample supply of oxygen is required to sustain burning. The temperature ranges given refer to a single strand of tape because there is no recognized test for rate of burning of magnetic tape in a roll.

Excessive heat causes deterioration of cellulose acetate and shrinkage of polyester. Polyester film, for instance, will shrink 1½% at 300°F.

If magnetic tape in a roll is heated to the following approximate temperatures and then cooled, the effects indicated will be produced:

250°F—distortion of backing

320°F—softening of both backing and binder and consequent cementing together of adjacent layers of tape

500-600°F—darkening and embrittlement of backing and binder

700°F (self-ignition temperature)—charring of backing and binder

The CO_2-type fire extinguisher is recommended for combatting burning magnetic tape. Since CO_2 is clean, there is no water damage to tape (water can cause swelling of cellulose acetate). Careful rewinding of fire-damaged tape at minimum tension will often restore the tape so that information on it can be transferred to another reel.

Accidental Erasure or Saturation

Magnetic properties of computer tapes are stable indefinitely. Signal retentivity is permanent unless altered magnetically. However, magnetic fields from permanent magnets or electro-magnets placed within a few inches of the tape can erase the recorded signal. Complete erasure (considered for purposes of this discussion to be reduction of signal to a point below the noise level of the system) does not usually take place unless the field is strong enough to exert a noticeable attraction for the tape, or to induce vibration in the tape. Slight erasure can occur, however, by proximity to current-carrying conductors without any noticeable attraction or vibration.

Both unrecorded and recorded tapes should be kept from electro-magnetic bulk erasers and storage cabinets that have magnetic latches. Unrecorded tapes should not be placed near d-c magnetic fields because they may become saturated and suffer signal degradation (i.e., their signal-to-noise ratio can be reduced).

Parts of the recorder can become magnetized; this also can cause tape erasure or possible tape saturation and signal degradation. Periodic demagnetization of critical recorder parts, particularly heads, is recommended.

Packing Tapes for Shipment

Tape can be packed with bulk spacing (such as wood) between it and its shipping carton to guard against accidental erasure of recorder tape during shipping. Assuming that no field greater than 1000 Oersteds will be encountered during shipment (an unverifiable, but reasonable, assumption), three inches of bulk spacing should give adequate protection.

Acknowledgements

The author is indebted to the following individuals and companies for their aid in compiling this material and in permitting re-publication of certain sections of their own literature: *Clarence B. Stanley* of Ampex Corporation, *Andrew Gabor* of Potter Instrument Company, the Minnesota Mining and Manufacturing Company, and E.I. du Pont de Nemours and Company.

References

1. Richards, R. K., *Digital Computer Components and Circuits*, Chapter 1, Van Nostrand Co., Princeton, N. J., 1957.
2. Truxal, John G., *Control Engineers' Handbook, Section 13*, McGraw Hill, New York, N. Y., 1958.
3. Gabor, Andrew, "Circuits and Logical Configurations of the Potter M921 Family of Transistorized Digital Magnetic Tape Record-Playback Amplifiers," Potter Instrument Company, Plainview, L. I., N. Y., 1959.
4. *"Technical Talk,"* Computer Bulletins 1 and 2, Minnesota Mining and Manufacturing Company, St Paul, Minn.
5. Stanley, Clarence B., *How Environment Affects Magnetic Recording Tape*, Ampex Corporation, Redwood City, Calif.
6. *How Magnetic Instrumentation Tapes of Mylar Provide Maximum Reliability*, E. I. du Pont de Nemours and Co., Wilmington, Del.

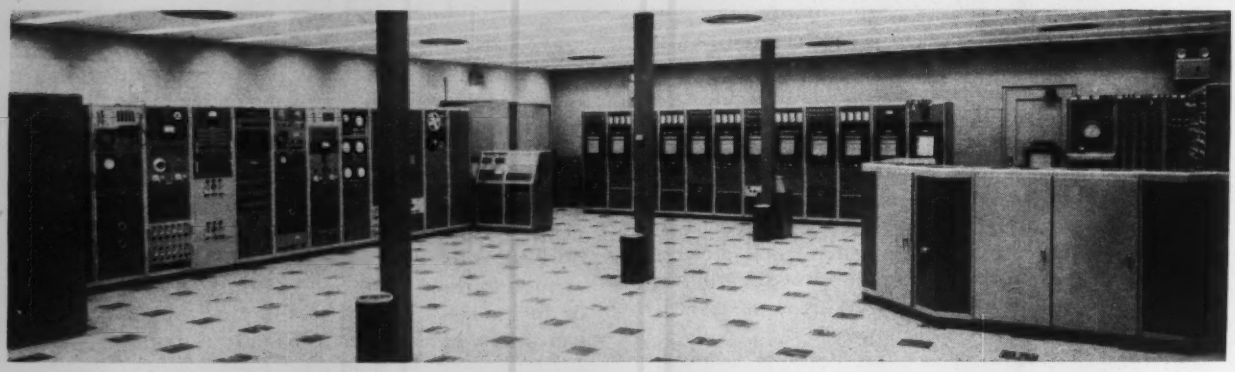


FIG. 1. DATA RECORDING CENTER (l. to r.): Stress monitoring equipment, interstage traversing equipment, and analog computer.

Data Recording and Processing

PAUL A. VERRETTE
General Electric Company

THE Flight Propulsion Laboratory Department of the General Electric Company's Flight Propulsion Division maintains extensive gas-turbine component test facilities in Lynn, Massachusetts. This article deals with the research component compressor test programs and emphasizes data-processing techniques.

Figs. 1 and 2 depict the centralized *Data Recording Center* from two vantage points within the Center. From here, any of seven test facilities can be monitored. Fig. 1 depicts the dynamic portion of the instrumentation which provides visual, graphic displays of test component performance. Viewing left to right are stress-strain monitoring equipment, interstage traversing equipment and a rear view of the analog-computer console. Fig. 2 is another view of the analog computer console on the left, followed by the hot-wire anemometry equipment and the digital data-recording systems on the right.

Fig. 3 shows ICPAC, a real-data, real-time analog computer which accepts real data in analog fashion directly from the compressor under test and continuously and instantaneously presents, in real-time, computed results of over-all test compressor performance. For this reason, the computer has been assigned the descriptive name ICPAC—Instantaneous Compressor Performance Analysis Computer.

Based on a paper presented at AGARD Avionics Panel Meeting. Aachen, Germany.

Fig. 3 shows the ICPAC as located in the Data Recording Center.

In operation, the computer monitors representative pressures and temperatures at the inlet and discharge planes of the test compressor, and at the inlet and throat of up to six airflow-metering nozzles. A signal proportional to actual compressor rotational speed is also supplied to the computer.

Acting upon these voltage analogs of test compressor conditions, the computer performs the necessary averaging of pressure and temperature data, generates applicable thermodynamic functions such as the nozzle restriction factor, and solves the equations governing over-all test compressor performance characteristics. At its output, the computer produces voltage signals proportional to:

Over-all compressor pressure ratio.
Adiabatic temperature-rise efficiency, in percent.
Total corrected weight flow, in pounds per second.
Corrected speed, in percent of design speed.

The computed output then may be monitored directly at the computer control panel and can be simultaneously programmed into any or all of three X-Y function plotters in any desired cross-plot arrangement. For example, we may plot: Pressure ratio versus total corrected weight flow, pressure ratio versus temperature rise efficiency, corrected speed versus total corrected weight flow, etc.

A real-data, real-time analog computer, as described, enables the design engineer to follow the aerodynamic intricacies of the test program. Dynamic trends and trend variations as the physical geometry of the test unit is altered are depicted continuously in suitably expanded scale units. Areas of doubtful or optimum performance worthy of detailed investigations become readily apparent.

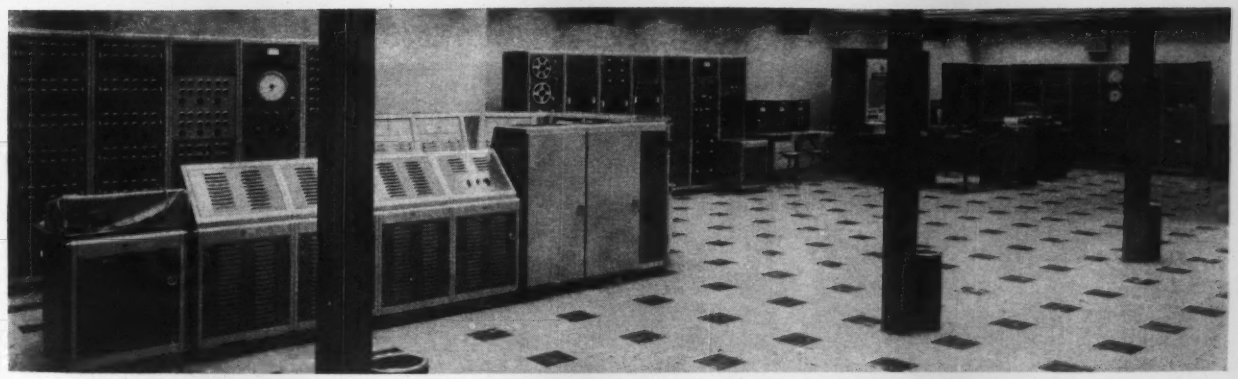


FIG. 2. DATA RECORDING CENTER (l. to r.): Analog computer, hot-wire anemometry equipment and digital data-recording systems.

in Aircraft-Gas-Turbine Evaluation

In addition, high-resolution, single-stage pressure ratio computers monitor individual stage performance as guides to the proper matching of the separate stages.

High accuracy is not a prime requirement of the computer; system accuracy, including sampling error, approximates 1% of reading at the higher speed range. Nevertheless, the computer is of material aid in establishing starting and running stator-vane schedules, in optimizing such stator-vane schedules at intermediate and design speeds, in acceleration and deceleration runs, and in stall investigations.

Stress Analysis

The continuing emphasis on higher thrust-to-weight ratio requires close supervision of all vibratory stresses.

From a mechanical viewpoint, visual displays of mechanical stress patterns are presented on a continuing basis, and are simultaneously recorded in analog fashion on magnetic tape for later detailed analysis.

Stress signals are generated by strain-gage sensors mounted on the stator vanes and rotor blades of the test compressor, as well as on the flexure mounts supporting the vehicle in the test stand. Operating as an 80-channel-capacity system, any group of 36 stress signals can be conveniently programmed into three 12-channel banks of 3″ oscilloscopes for rapid, on-the-spot interpretation of the stress patterns as shown by their frequency composition and strain amplitude.

Fig. 4 shows the stress-strain indicating and recording system in the Data Recording Center. This includes the magnetic tape packages, the program board, the 12-channel visual display units, analyzing equipment, calibration equipment, additional analyzing equipment, auxiliary monitors, etc.

Oscillographic techniques are used also for investigating system vibration and resonance phenomena for later manual analysis and interpretation.

Additional Monitors

Additional instrumentation monitors are normally provided to further ensure safe operation of the test component. For example, hot-wire anemometry is used for detecting stalls, both prominent and incipient, which are generally localized and not otherwise detectable.

Wide-strip chart recorders, operating on a common time base, also record vibration levels, speed variations and certain dynamic pressure and temperature parameters peculiar to a special line of investigations.

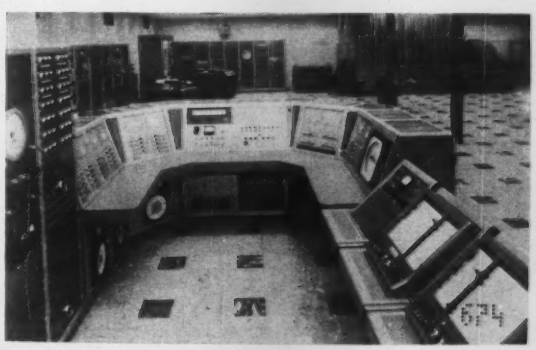


FIG. 3. INSTANTANEOUS compressor performance analysis computer (ICPAC) located in data recording center.

FIG. 4. **STRESS-STRAIN** monitoring equipment, including 12-channel visual display units, 40-channel barscope, and analyzing equipment.

Final Data Processing

All instrumentation mentioned thus far has been of a guidance nature to ensure safe mechanical operation and to perform preliminary data analysis. One of the specific test objectives, that of defining a comprehensive compressor performance map, then is realized through the application of automatic data recording systems linked directly with a large-scale digital computer for on-the-spot computation.

Upon entering some area requiring detailed aerodynamic investigations, the test component is set to a desired operating condition, as portrayed by preliminary analog-computer data, and permitted to stabilize while holding speed and all other controllable variables constant.

On command, two automatic data recording systems (Fig. 5), operating in parallel, sequentially scan all research test pressure and temperature data and digitize them to an arbitrary number scale. Both recording systems generate typewritten "hard" copies within the Data Recording Center. Simultaneously, IBM cards are automatically punched, via telephone transmission lines, at the IBM 704 computing center located more than half a mile away.

Upon scan completion, the punched-card data are immediately processed by the 704 computer. All computer programs normally processed during our testing periods incorporate interrupt features. Top priority test data are processed upon scan completion by dumping the running program into temporary storage. Our data are processed with selected on-line printout of performance results. The 704 computer then is returned to its interrupted program. In this manner all the advantages of an on-line digital computer are achieved without significant increase in cost.

Our nominal 3.5-minute computer program performs the following major analyses: (1) Converts the arbitrarily-scaled data into absolute units; (2) edits data on a comparative basis—preliminary manual data editing having previously been done during the scan cycle by reference to the typewritten "hard" copies; (3) corrects all temperature data for static deviations and velocity effects; (4) computes over-all performance such as compressor pressure ratio, thermal-rise efficiency, total corrected air-weight flow based upon both flow nozzle and bellmouth measurements; (5) determines a bellmouth flow coefficient for future use in complete engine testing; (6) computes individual stage performance including blade loading; (7) generates a "bad" data format, based on the editing routine for subsequent trouble-shooting; and (8) tabulates pressure transducer sensitivity

FIG. 5. **AUTOMATIC DATA RECORDING SYSTEMS** for 200 temperatures and 400 pressures.

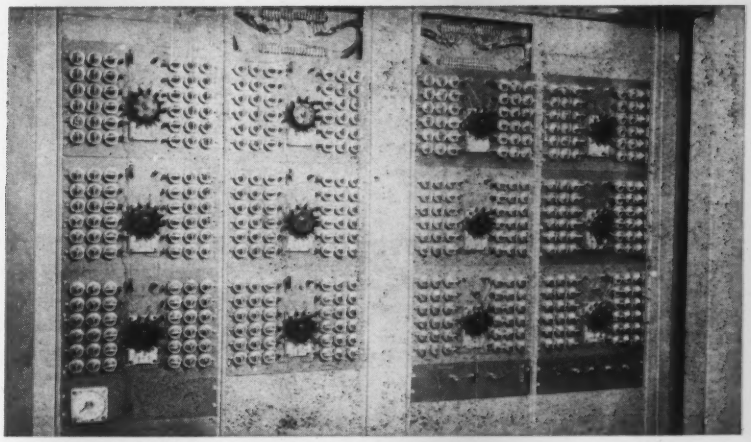


FIG. 6. PNEUMATIC SCANNING SYSTEM. Any one of three test facilities can be selected for pressure instrumentation.

factors as an aid in assuring pressure data validity. Data and results that have been selectively printed on-line during program execution are re-transmitted to the Data Recording Center via facsimile transmission techniques.

Under favorable conditions, the over-all data-logging and computing cycle is completed within 10 minutes. This time cycle is fully compatible with present compressor testing techniques.

Each of the two automatic data recording systems previously mentioned has an intrinsic channel capacity for 200 temperature data and up to 400 pressure data. In normal use, one system is assigned to temperature data and the other to pressure data. This technique proportionately reduces the over-all scan time. However, should one system malfunction during test, the second system then can assume all recording functions by a switch command.

The economics of large-scale component compressor tests warrant duplication of prime recording and monitoring equipment. Duplication of equipment is a major step toward the ultimate in system reliability— effectively providing 100% spare parts. In event of malfunction, the defective system may be taken off-line for corrective action while the test progresses.

Fig. 6 depicts a segment of the pneumatic scanning system which is centrally located with respect to the test facilities. Commercially-available pressure scanners, suitably programmed, supply each of twelve pressures in sequential order to a common pressure transducer. The present transducing system employs variable-reluctance, carrier-excited pickups with a d-c analog of pressure output. Among the advantages of the pneumatic pressure-scanner installation and its quick-connect fixtures are fast facility selection, flexible programming, and convenient transducer replacement.

A comparable thermocouple switching center (left rack of Fig. 5) also provides for convenient facility selection and for individual check of thermocouple output into a high-resolution millivolt standard. Provisions are also made for switching thermocouples onto averaging busses providing arithmetic averages of temperatures for use by the analog computer.

Semiautomatic Instrumentation

Interstage radial traverses are performed during some phases of the compressor test programs (Fig. 7). Here, multi-parameter probes are traversed across instrumentation stations of interest to generate co-planar traces of pressure, temperature and flow angle profiles as function of the radial immersion. The resultant graphic representations serve an immediate purpose to the aerodynamicist from a qualitive view-point. However, such X-Y function plots are subject to extensive interpretation by semi-automatic translation of the analog plots into IBM punched cards for subsequent processing through an IBM 704 computer. Such data have their maximum value for detailed aerodynamic studies of stage performance and stability, and as a possible source of malfunction investigations.

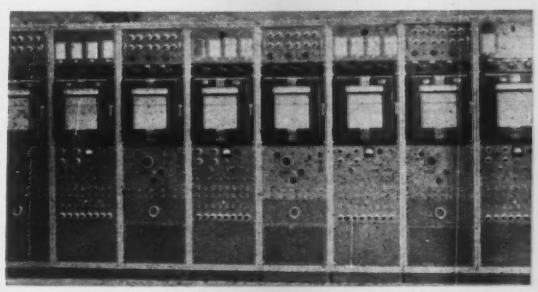


FIG. 7. INTERSTAGE TRAVERSE instrumentation system.

STATISTICAL TECHNIQUES

W. A. JASSON
Airborne Instruments Laboratory
Division of Cutler-Hammer, Inc.

Statistical techniques are becoming increasingly important in (1) evaluating performance, reliability and accuracy, (2) determining confidence level and significance, and (3) designing experiments and analyzing results.

Terminology

Confidence Level—Expresses (in %) the probability that a given assertion is true, that it lies within certain limits calculated from the data; a degree of certainty.

Dispersion—The scatter of values.

Frequency Distribution—Plot of number of occurrences of particular values against those values.

Mean—The arithmetic average; $\bar{x}$ for a sample, $\bar{\bar{x}}$ for a population. Equals $\Sigma x/n$.

Median—The value above which, and below which, half the values lie.

Mode—The most frequent value. Peak on the frequency-distribution curve.

Population—The entire group being studied, from which samples are drawn. This can be a production lot, readings on an instrument, tests on equipment, results of a test, etc.

Range (R)—Difference between highest and lowest observation.

Sample—A limited number of items selected at random from a population.

Standard Deviation (σ, s)—Measure of the dispersion of values.

$$s = \sqrt{\Sigma(x - \bar{x})^2/(n - 1)} = \sqrt{\text{Variance}}$$

Variance—Square of the standard deviation

$$= \Sigma(x-\bar{x})^2/(n-1)$$

WILBUR A. JASSON holds a mechanical engineering degree from New York University, College of Engineering (1950), plus graduate work in electrical engineering and industrial management (including statistics) at NYU and at Columbia. In 1950, Mr. Jasson joined RCA at Harrison, New Jersey, assisting in the development of new UHF transmitting tubes, including quality control. In 1953, he became Director of Quality Control for Micamold Electronics, division of General Instruments Corp. In 1958, Mr. Jasson joined Airborne Instruments Laboratory. He is Supervisor of the Reliability Laboratory, which evaluates components and design techniques for effects on system reliability. Mr. Jasson is a Senior Member of the Institute of Radio Engineers.

THE mounting complexity of control systems and space-age instrumentation forces statistical techniques into the forefront of vital analytical methods. Statistical methods permit tests and experiments to yield the most information from the least experimentation; they permit better evaluation of data by significance testing, and by the designation of confidence levels. (Even the most competent engineering designs or analyses, being based on finite data, carry confidence levels less than 100%.) Statistical techniques also make possible the calculation of the degree of reliability of a given system. The power of the technique lies in the fact that it is the one means by which we can interpret and use variation.

Variation is universal. Everything is subject to continual change (even if infinitesimal) in differing degrees, sometimes slow and unnoticed, other times as dynamic and explosive as the advent of twins or of blown fuses (personal as well as electrical). Yet the human mind seeks order and stability, a thread of meaning somewhere in the general chaos, in the knowledge that orderliness and organization does exist in the universe. Two basic questions lead to the development of statistical methods:

1. Is there *pattern* in chance variation?
2. Assuming such pattern exists and can be expressed mathematically, can we determine what to *anticipate* and what seems outside the area of chance for a given situation?

Pattern

Suppose that 10K-ohm carbon composition resistors are coming off a production line. Twenty units are picked at random and checked on an ohmmeter, with results shown in Table 1. (Always attempt "random" sampling, such that each unit of the population has an equal chance of being chosen for the sample.)

Plotting the data of Table 1 gives Fig. 1. The dotted line represents a particular *frequency distribution* which is already taking form from this limited amount of data. This curve is the "normal" or "Gaussian" curve, representing the useful general pattern of chance or "natural" variations (including repetitive readings of some electrical or mechanical measurements).

In Fig. 1 also can be seen a little-realized hazard in specifying tolerances. If you buy component parts to a loose tolerance, your order probably will be filled from residual units after all tighter-tolerance orders have been filled. You will thus receive units falling into the tail areas shown. It is therefore advisable to specify part tolerances only after determining what *range* of values your circuits (or mechanical assemblies) will tolerate, allowing a margin of safety.

Anticipating Values

How can we identify the frequency distribution so that we can anticipate the spread of values?

We can describe a distribution primarily by the use of two measures—the *mean* and the *standard deviation*. The *mean* is a measure of "central tendency." That is to say, it is the value about which most of the observed values tend to cluster. In Fig. 1 the mean would be approximately 9.93. Denoted by the symbol $\bar{x}$ for a sample, and by $\bar{\bar{x}}$ or the Greek letter μ for the entire population, it is what the layman often calls the "average." Other measures of central tendency are the *median* (the value above which, and below which, 50% of all values lie) and the *mode* (the most frequent value, or the peak of the frequency-distribution curve).

In Fig. 2, A and B show relative values of $\bar{\bar{x}}$ for two arbitrary normal distributions; C shows a "skewed" distribution, resembling the normal, but asymmetric (it is skewed to the left).

The *standard deviation* is a measure of the dispersion, or spread, of the distribution. It is denoted by the Greek letter σ (or sometimes by small "s" for sample values). It can be estimated from the *range* (R), which is merely the difference between the highest and lowest observations, but this value is greatly affected by extreme or "freak" values. It is usually better estimated from the relationship $s = \sqrt{\Sigma (x - \bar{x})^2/(n-1)}$, where x is an individual value and n is the number of observations.

$\bar{\bar{x}}$ and σ are important statistical "parameters" that apply to entire populations of data. However, one can work out their values from a knowledge of the corresponding sample values. Thus the population parameters $\bar{\bar{x}}$ and σ can be estimated from relevant statistics ($\bar{x}$ and s) of samples drawn from that population.

From integral calculus we know that if a curve can be characterized mathematically, any given area under that curve can be expressed in terms of a percentage of all values represented by the curve. For a normal distribution (Fig. 3), which can be characterized by its mean and standard deviation,

TABLE I—COUNT OF RESISTORS HAVING VARIOUS RESISTANCE VALUES

Resistance	No. of Units	Resistance	No. of Units
7.5K	0	10.5	2
8.0	2	11.0	3
8.5	1	11.5	1
9.0	2	12.0	0
9.5	4	12.5	1
10.0	4		

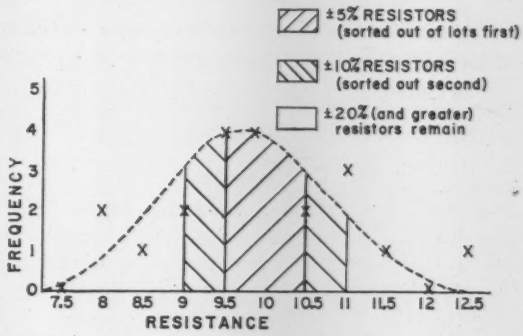


FIG. 1. PLOT of frequency (number of resistors) against resistance value roughly approximates "normal" frequency distribution (dotted line).

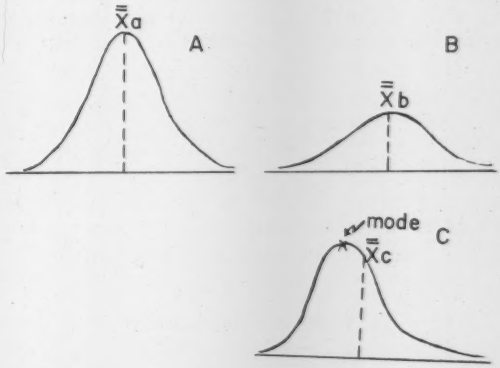


FIG. 2. A AND B show normal (Gaussian) frequency distribution where mode, mean, and median have the same value. Curve B is spread more; its standard deviation is greater than that of curve A. C shows frequency distribution skewed (asymmetric) to the left.

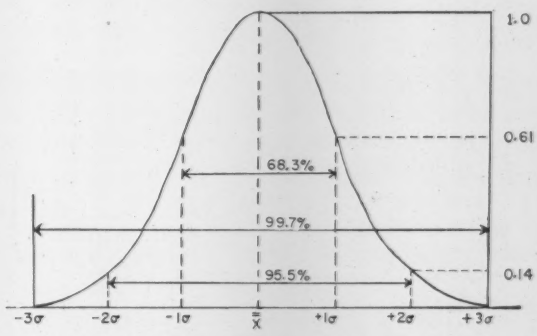


FIG. 3. PERCENTAGE of events falling within 1-, 2-, and 3-sigma limits for a population characteristic that has a normal distribution.

TABLE 2—POPULATION PERCENTAGES BETWEEN $\bar{\bar{x}} \pm n\sigma$ LIMITS UNDER NORMAL CURVE

n	%	n	%
0.5	38.3	2.0	95.5
1.0	68.3	2.5	98.8
1.5	86.6	3.0	99.7
1.65	90.0	3.2	99.9
1.96	95.0	3.6	100.0

it can be shown that 68.3% of the population will lie within the limits of $\pm 1\sigma$ from its mean ($\bar{\bar{x}}$), 95.5% will lie within $\bar{\bar{x}} \pm 2\sigma$, and 99.7% will lie within $\bar{\bar{x}} \pm 3\sigma$, as shown in Table 2.

Confidence

Statistical "confidence," and the terms "confidence level," "confidence limits" and "confidence interval," also refer to these percentages. Suppose "90% confidence" is cited for a reliability figure calculated for a particular control system. This acknowledges that our confidence in our results is less than complete; it indicates 90% certainty.

If we seek from a set of data a 90% confidence interval for the mean, we seek the "$\bar{\bar{x}} \pm 1.65\sigma$" limits under a normal curve representing that data (Figure 3). Although this assumes the distribution to be normal, we often can obtain a decent approximation for non-normal distributions, provided the confidence interval is symmetric.

If we are working with mean values, we can disregard normality considerations altogether, because mean values are almost always normally distributed, regardless of the parent distribution. If we know the distribution to be *non-normal*, we can base our considerations on Tchebycheff.

Tchebycheff Inequality

Despite the convenience of working with distributions which are normal, many distributions steadfastly refuse to be normal. Our greatest weapon in such cases is the *Tchebycheff Inequality*, which applies to any distribution whatsoever (provided the standard deviation exists). Also available is the *Camp-Meidell Inequality*, which applies if there is but one peak value (or "mode") which must be equal to the mean, with frequencies declining continuously on both sides of that mode.

Tchebycheff states that a fraction greater than $(1 - 1/t^2)$ of any group of numbers must lie within the limits $\bar{\bar{x}} \pm t\sigma$, where "t" is any multiple of σ equal to or greater than unity. To illustrate, if we apply this to limits of $\bar{\bar{x}} \pm 2\sigma$, the fraction will be $(1 - 1/2^2)$ or ¾. This means that better than 75% of any population whatsoever must lie within 2σ limits, *the shape of the actual distribution notwithstanding.*

Camp-Meidell Inequality

We can improve on Tchebycheff's formula if we know three things— (1) that there is but one peak value or "mode" (we may assume a small range of values to be a collective mode), (2) that this value is roughly equal to the mean, and (3) that frequencies decline continuously (although perhaps not equally) on both sides of the mode. We can then apply the *Camp-Meidell Inequality*, stating that a fraction greater than $(1 - 4/9t^2)$ of any distribution meeting these three requirements must lie within the limits $\bar{\bar{x}} \pm t\sigma$.

The two inequalities and the normal distribution are compared in Table 3.

TABLE 3—MAXIMUM POPULATION PERCENTAGES THAT FALL OUTSIDE EACH SET OF LIMITS

LIMITS	TCHEBYCHEFF	CAMP-MEIDELL	NORMAL
$\pm 2\ \sigma$	25.0	11.1	4.55
$\pm 2.5\sigma$	16.0	7.1	1.24
$\pm 3\ \sigma$	11.1	4.9	0.27
$\pm 3.5\sigma$	8.2	3.6	0.05
$\pm 4\ \sigma$	6.3	2.8	0.006

We thus can analyze and predict variations in any one population. We can determine (1) whether a set of conditions or results (the population) has changed (we do this by taking samples, calculating their statistics and comparing with other sample statistics or with estimated population parameters), or (2) what the chances are of obtaining a particular value from the population. This is the basis also of various statistical "significance tests" which find so many effective uses. It may be of interest to note that the control chart used in quality control of production operations is itself actually a running "significance test" on variations in product measurements. All statistical sampling plans are significance tests of a sort.

Reliability Studies

As system complexity increases, the difficulty (and necessity) of measuring system reliability mounts. Statistical methods are required. First, we must establish the system's "reliability diagram" (a chain diagram showing interdependencies with respect to the ability of one part or circuit to perform when another malfunctions). Then we are ready for calculations utilizing the mathematics of probability and "hazard rates." Hazard rates represent quantitatively the expected failures of component parts within each segment of the reliability diagram and are often expressed in failures per million hours. The low confidence levels of hazard rates, although improving, remain a limiting factor in reliability calculations.

For reliability studies of systems and the determination of system tolerances (both electrical and mechanical), a particularly useful statistical theorem is this: For a *linear* relationship of independent variables, the over-all value of the "variance" (the square of the standard deviation) equals the sum of the variances of the parts, always provided these variances are random and independent. The importance of this lies in the fact that it provides a way of making dispersions (including tolerances) additive. (If the relationships are *not*

linear, the solution involves partial differentials in a combined mathematical and experimental approach.) If we know the range of values (or tolerances) desired, expected or permissible for one or more such variables, and we seek to determine similar ranges for other variables, the following procedure was found by the author to be effective, especially in reliability applications:

1. Convert each known range of variation into a standard deviation (estimate from $\sigma = R/d_2$, where d_2 is a factor that varies according to n and is available from standard tables). If a normal distribution cannot be safely assumed, such conversion can be made on the basis of Tchebycheff or Camp-Meidell.
2. Equate (using symbols, not numbers) the total squared standard deviation to the sum of the squared standard deviations of the parts—in other words, the total variance to the sum of parts' variances.
3. Assign values to all unknown variances except the one which is "most" unknown; do this by trial and error, extrapolation, estimation, analogy, juxtaposition or, failing these, by intuition or faith.
4. Solve for the remaining variance mathematically.
5. Steps 3 and 4 may now be repeated as often as necessary to obtain closer values of each σ^2.
6. Convert the variances obtained into ranges (tolerances), estimating from $R = \sqrt{d_2^2 \sigma^2}$, where d_2 is again determined (and the distribution considered) as in step 1.

Other major areas of application of statistical method include: *regression*—the estimation (usually *graphically*) of one variable from a knowledge of another; *correlation*—evaluation of the degree of association of variables; and the *design of experiments*, including analysis and interpretation of experiment results.

Design of Experiments

In the classical experimental approach, we determine the reactions of one variable while holding all other variables constant. The trouble with this approach is that (1) with variables held constant at particular levels, no knowledge can be gained of effects at other levels, and (2) interactions among the variables cannot be evaluated. Under the classical approach, additional experiments must be conducted to obtain that information, and often the results are unmanageable anyhow.

Statistical design of experiments makes interaction information readily available and usually provides the most information from minimum experimentation. Results can be automatically in a form suitable for analysis and interpretation by a method called the *Analysis of Variance* (this variance is the same one that we already defined as σ^2). We then can determine the existence and extent of interactions among the variables, as well as the significance of the results.

Pertinent to the design of experiments are a whole family of terms, concepts and techniques—*least squares, replications, randomized blocks, confounding, Latin Squares, factorial and lattice designs, etc.* Definitions and a coverage of the entire subject, and of the analysis of variance and many other applications of statistical method, can be found in the references cited in the bibliography.

Bibliography

Brownlee, K. A., *Industrial Experimentation*, Chemical Publishing Co., 4th ed., 1952

Cochran, W. G., and Cox, G. M., *Experimental Designs*, John Wiley, 2nd ed., 1957

Cramer, H., *The Elements of Probability Theory*, John Wiley, 1955

Enrick, N. L., *Quality Control*, Industrial Press, 3rd ed., 1959

Fisher, R. A., *The Design of Experiments*, Hafner, 6th ed., 1951

Grant, E. L., *Statistical Quality Control*, McGraw-Hill, 1946

Hoel, P. G., *Introduction to Mathematical Statistics*, John Wiley, 2nd ed., 1954

Johnson, P. O., *Statistical Methods in Research*, Prentice-Hall, 1949

Kempthorne, Oscar, *The Design and Analysis of Experiments*, John Wiley, 1952

Waugh, A. E., *Elements of Statistical Method*, McGraw-Hill, 2nd ed., 1943

Addition to Precision Pressure Gage Review

Fulton Sylphon Division of Robertshaw-Fulton Controls Company offers a test gage (Fig. 1) in their Acragage line that provides accuracy of 0.25% of full scale. Solid-front safety construction is standard. Sixteen ranges are available, from 0-15 psi to 0-10,000 psi. Bourdon materials can be bronze, alloy steel, or stainless steel. Dial sizes can be 4½", 6", 8½", or 12". Capillary bleeder for flushing bourdon tube is optional.

Acragage line also includes potentiometer transmitters and electric pressure-gage receivers (Fig. 2) for remote indication. Bellows models are available for 0-30" Hg and 0-15 psi and 0-30 psi.

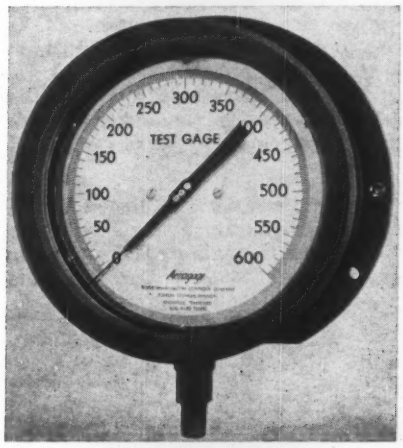


FIG. 1. ACRAGAGE test gage.

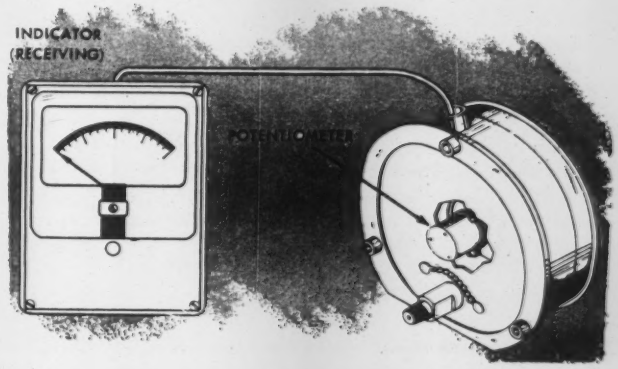


FIG. 2. ACRAGAGE transmitter and receiver.

Measuring ranges	Compensator ranges	Max. limits of error
0-16.1 millivolt	0-1.1 millivolt	0.01 millivolt
0-16.1 millivolt	0-5.5 millivolt	0.02 millivolt
0-80.5 millivolt	0-1.1 or 0-5.5 millivolt	0.05 millivolt

Rubicon Model 2745 portable potentiometer. Price: $425, F.O.B., Philadelphia. Write for Specification Sheet RS 2745a.

This potentiometer has permanent accuracy*

It's possible to achieve impressively high potentiometer accuracy in one-shot tests under ideal laboratory conditions. And that is exactly how the advertised accuracies of some instruments are attained.

Not so with Rubicon potentiometers. These are instruments you can count on for consistently stable, reproducible accuracy for their entire life. This accuracy is created by careful engineering and superb craftsmanship, not by premium-priced gimmicks.

A case in point is our Model 2745 portable potentiometer, shown above. Its exceptionally narrow limits of error will apply every time you use the instrument . . . today and years from now. Incidentally, this is the only portable potentiometer that extends reference junction compensation to the entire range of sub-zero measurements. It enables you to make a continuous series of measurements above and below the table reference temperature, without readjusting the compensator or reversing the leads. And its built-in Pointerlite galvanometer is sensitive enough to permit balancing to ± 0.002 millivolt in circuits up to 15 ohms.

This fine potentiometer and the entire Rubicon line of precision measuring instruments are available through Honeywell sales offices across the nation. MINNEAPOLIS-HONEYWELL, Ridge Avenue at 35th St., Philadelphia 32, Pa.

Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

CIRCLE 85 ON READER-SERVICE CARD

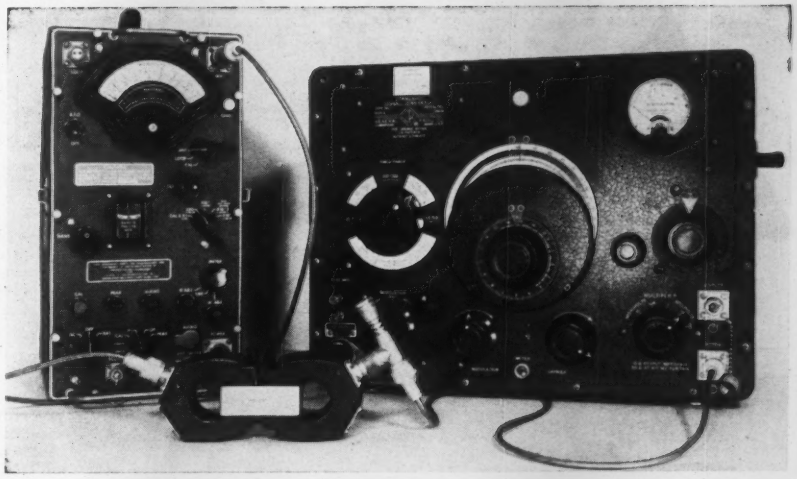


FIG. 1. RADIO-FREQUENCY INTERFERENCE (RFI) meter (left) used to measure impedance of an A-C line, using a standard signal generator (right) and current transformer (front).

INTERFERENCE and THE RFI METER

Accurate RFI measurements demand careful consideration of the type of signal measured, the RFI meter used, and the accuracy to which the meter is calibrated. This article discusses interference sources, the RFI meter, and calibration set-ups.

H. A. FAVORS, R. E. BLOOM, R. J. FLEISCHER, Stoddart Aircraft Radio Co., Inc.

RADIO INTERFERENCE is any electromagnetic disturbance which can cause undesirable response, malfunction, or detrimental operation of electronic or electrical devices. It may be broadband or at a fixed frequency. It may show a random frequency characteristic, or it may recur at regular intervals. It may result from (1) deliberate radiation, such as jammers, (2) the operation of devices such as motors and generators, (3) natural phenomena such as lightning discharges, solar radiation, or even the stars. Interference can be either radiated or conducted from its source.

Types of Interference

Interference signals are grouped into *narrowband* (cw) or *broadband* types, the former so called because it is at a single radio frequency, while the latter possesses appreciable energy throughout a band of frequencies. Broadband interference is further divided into random and impulse.

Impulse interference is distinguished by having a spectrum that is broad compared with the nominal bandwidth of the interference (noise) meter being used to measure the interference. Random interference, on the other hand, consists of disturbances without regularity in amplitude, phase and occurrence. Random interference occurs at a random pulse rate and at random levels.

Sources of Noise and Interference

Thermal Noise

Thermal noise in the input to an r-f circuit is a key source of trouble. It is random in nature and expressed by:

$$P = 4KTBR$$

where B = effective bandwidth in cps, R = source resistance, K = 1.37×10^{-23}, T = degrees K (273° at 0°C).

New officers for PMA:
President: HOWARD KEMP, Borg-Warner Controls
Vice President: PHILLIP PAINCHAUD, Nortronics, Systems Support Div. of Northrop Corp.
Secretary: HUNTER McCONNELL, Cal Tech Jet Propulsion Laboratory
Treasurer: A. K. EDGERTON, Western Instruments
Board of Directors: CLIFF KOOP, Autonetics; FRANK THOMA, General Radio Company
Next meeting: September 6, 1961, Michael's Restaurant, 6309 East Washington Blvd. (north of Santa Ana Freeway).

This paper was presented before the Precision Measurements Association

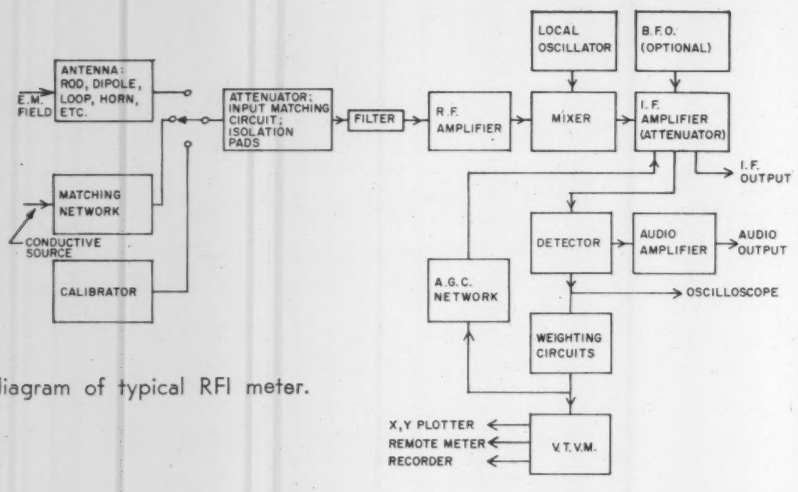


FIG. 2. BLOCK diagram of typical RFI meter.

Thus, as voltage varies as the square root of the power ratio,

$$V = \sqrt{4KTBR}$$

thermal noise voltage varies as the square root of the bandwidth of the receiver. Impulse interference, on the other hand, is directly proportional to bandwidth, as previously mentioned.

Atmospheric Noise

Noise of atmospheric origin is erratic in character, consisting of short, randomly recurring pulses superimposed on a background of random noise. The average power level is relatively constant during a given hour, but may vary considerably over the day. The noise tends to decrease with increasing frequency*, becoming negligible at the high frequency end of the band, and is rarely distinguishable from receiver thermal noise above 30 megacycles. In tropical and temperate latitudes atmospheric noise tends to be the highest in summer and lowest in winter. Levels of noise during various seasons can be found in NBS Circular 557, normalized to 100-cycles bandwidth in terms of standard units (db above 1 microvolt per meter).

Galactic Noise

Radio waves from galaxies outside the solar system are important as interference sources below 30 megacycles. The maximum intensity received is from the direction of the Constellation Sagittarius. Due to atmospheric screening, the noise level received depends on the ionospheric absorption characteristics and the operating frequency. The noise levels are generally negligible below 1 megacycle and vary with the geographic location and sun-spot cycle phase.

Corona and Precipitation Static

Precipitation static and corona discharge are often of high amplitude and produce an extensive spectrum of interference. Such static charges are built up by impact with precipitation, dust, sand or smoke particles, and by induction from surrounding charged clouds. The discharge is most severe in the low- and middle-frequency regions and may be present at aircraft extremities or over the entire airframe structure.

Man-Made Interference

Typical of man-made interference is that emanating from radar transmitters, receiver local oscillators, and digital devices such as computers, electrical apparatus, dynamotors, inverters, d-c motors, etc.

The RFI Meter

An RFI meter is shown at the left in Fig. 1, and outlined in block-diagram form in Fig. 2. It is similar in many respects to a standard receiver. The difference lies in the many refinements of the RFI meter and the accessory equipment necessary to measure radio interference and field intensities to within accuracies required by Military interference specifications.

Some of these refinements consist, for example, of (1) loop, whip and adjustable folded dipole antennas whose gain characteristics have been precisely measured and calibrated, (2) pick-up devices of various types, and (3) special networks required to couple the signal from the antenna to the receiver input. Refinements in the receiver itself consist of a calibrating source, a coaxial attenuator, filters, isolation pads, special IF-amplifier circuitry and unique output circuits which contain special detector functions necessary to maintain response to interference specification requirements.

Three detector functions—field intensity (FI), quasipeak (QP), and slideback peak—are selectable from the RFI-meter front panel. The field-intensity function is employed in measurement of narrowband (cw) signals. The QP function is employed along with the FI and peak function to identify between random and impulse type noise. The QP function, in addition to measuring percent-

*Data derived from: Natural Bureau of Standards Circular No. 462, "Ionospheric Radio Propagation and Radio Propagation Unit," Report No. 3, NBS, Washington 25, D. C.

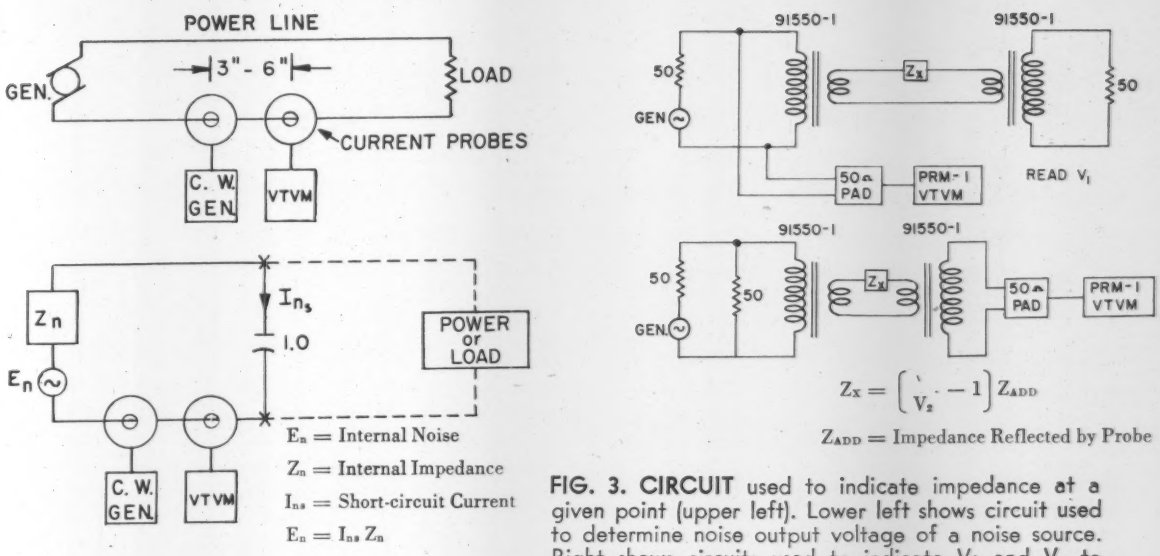


FIG. 3. CIRCUIT used to indicate impedance at a given point (upper left). Lower left shows circuit used to determine noise output voltage of a noise source. Right shows circuits used to indicate V_1 and V_2 to determine $Z_X = (V_1/V_2 - 1)\ Z_{add}$, and Z_{add} is the impedance reflected by the probe.

age modulation, is useful in performing rapid near-peak measurements. Slideback peak is employed when measuring impulse-type signals whose spectrum covers a frequency greater than the bandwidth of the IF amplifier.

In addition to the full 4½" meter scale located on the instrument front panel, special outputs are provided for audio, oscilloscope, I-F amplifier, remote meter and X-Y plotter. These features offer unique capabilities as follows:

1. The oscilloscope output provides means for observing signals.
2. The I-F output provides for connection to external devices such as panoramic displays and high-frequency oscilloscopes and provides an increase in C-W sensitivity simply by connecting the I-F output from one RFI meter to the input of another meter possessing a more narrow bandwidth.
3. A jack is provided for a remote meter to facilitate monitoring of equipment read-out remote to the RFI instrument.
4. An X-Y plotter output is provided for plotting amplitude **versus** frequency as a permanent record.

A-C Line Impedance Measurement with an RFI Meter

An RFI meter can be used to measure the impedance of an a-c power line.

Several methods of measuring A-C line impedance exist. However, for one reason or another, results have proven to be unsatisfactory, possibly because measurement data cannot be accurately repeated.

Stoddart Aircraft, in conjunction with Don Clark, U. S. Naval Civil Engineering Laboratory, has measured power-line impedance through the use of two current transformers clamped around a test sample conductor, using the principle of the current transformer (a low-impedance transformer whose secondary turns comprise one winding of a transformer; the test sample conductor lead, around which the transformer is clamped, comprises the other winding). Fig. 1 shows a radio-frequency interference and field-intensity meter used with a standard signal generator and a current transformer, for measurement of the impedance of an a-c line.

Stoddart engineers have found that the transfer of energy between two probes adjacent to each other can be predicted mathematically and measured accurately, and that the transfer of energy is a function of the coupling impedance between the two. Accordingly, a test has been established and the transfer of energy for various coupling impedances determined employing a c-w signal generator applied to one probe and the output from the second probe connected to an interference and field-intensity meter, as shown in Fig. 1.

Measurement procedure consists in clamping the probes around the test sample conductor, 3" to 6" apart. The c-w signal applied to one probe is measured and compared with the induced signal into the second probe. The amount of coupling loss between the two probes is then a function of the impedance (Z_X) of the test sample conductor.

Figs. 3A and 3B show application of the Stoddart Current Probe. In 3A, Z_X is the impedance of the test sample, and Z_{add} is the transfer impedance of the probe.

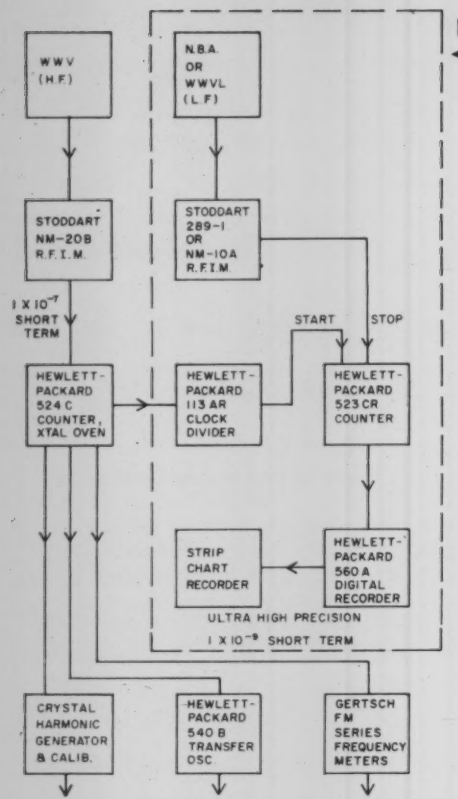


FIG. 4. EQUIPMENT for frequency measurement.

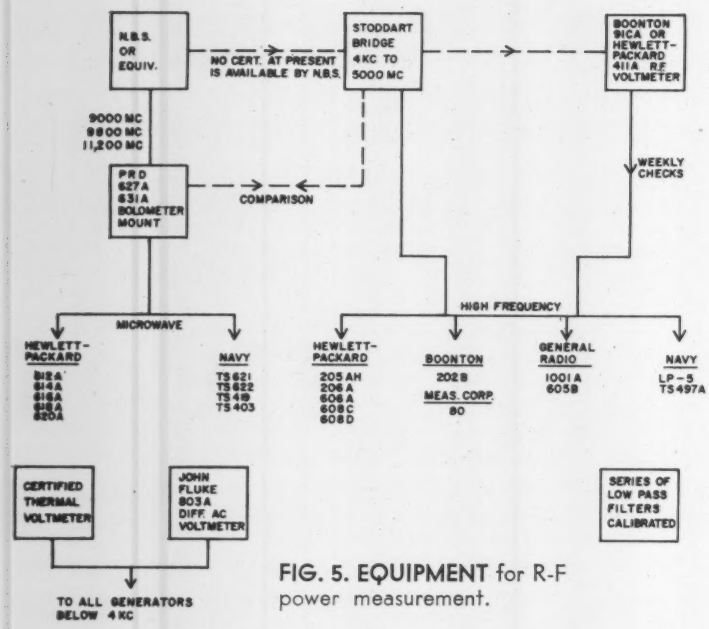

N.B.S. OR EQUIV.
NO CERT. AT PRESENT IS AVAILABLE BY N.B.S.
STODDART BRIDGE 4KC TO 5000 MC
BOONTON 91CA OR HEWLETT-PACKARD 411A R.F. VOLTMETER
9000 MC 9800 MC 11,200 MC
PRD 627A 631A BOLOMETER MOUNT
COMPARISON
WEEKLY CHECKS
MICROWAVE
HIGH FREQUENCY
HEWLETT-PACKARD
NAVY
TS621 TS622 TS419 TS403
HEWLETT-PACKARD 205 AM 206 A 606 A 608 C 608 D
BOONTON 202 B
MEAS. CORP. 80
GENERAL RADIO 1001 A 605 B
NAVY LP-5 TS497A
CERTIFIED THERMAL VOLTMETER
JOHN FLUKE 803 A DIFF AC VOLTMETER
SERIES OF LOW PASS FILTERS CALIBRATED
TO ALL GENERATORS BELOW 4 KC

FIG. 5. EQUIPMENT for R-F power measurement.

RFI Standards and Equipment Calibration

The problems in calibrating both standards and working RFI equipment has been an uphill struggle for many years. For example: Frequency calibration today is simple when accuracy on the order of 1×10^{-4} or 1×10^{-5} is needed. Any quality electronic counter with a stable crystal oscillator adjusted to beat with WWV can be used. (WWV is received at typical short-term accuracy of 1×10^{-7}. For ultra-high precision, transmissions on VLF from WWV or NBA will provide accuracy of 1×10^{-9}, short term, and 1×10^{-10} with longer observations, utilizing special equipment.) Fig. 4 shows techniques and equipments for R-F frequency measurement.

High-frequency power measurements (Fig. 5) are not so easily obtained. First of all, the National Bureau of Standards does not, at present, certify power devices, except waveguide mounts at 9000 Mc, 9800 Mc, and 11,200 Mc. Second, commercially-available power bridges have error tolerance generally on the order of 5% of full-scale reading. This error, plus the error of the mount used with the bridge, can total 15% or higher. High-precision measuring systems, such as the Engen or Weinschel equipment are available, but R-F mounts (heads) are not furnished at this time for the lower frequencies.

The Weinschel system was designed as part of a companion R-F voltmeter to provide high accuracy from —15 dbm to —107 dbm for calibration of attenuators. The Weinschel reference is a 1.000-milliwatt level to be set up at X band with an NBS-certified mount. No mounts are furnished at this time, although at lower frequencies the Stoddart mount (described later) lends itself to this application.

Audio Substitution Method vs. the Subtractive DC Method of Bridge Measurement

Resistance-type bridges have been used for the measurement of low-level R-F power for many years. As compared with calorimetry equipment, bridges have the advantage of higher sensitivity. Typical circuitry in common use consists of a Wheatstone-type bridge in which one arm of the bridge is a temperature-sensitive element such as a thermistor or barreter. The more popular commercially available bridges, for general use, employ a method of d.c. with audio-biasing feedback to enable direct read-out of power on the meter. This technique is called the *Audio Substitution Method* (Fig. 6). Another method, called the *Subtractive DC System* (Fig. 7), is essentially the substitution method, but differs from the audio substitution method in that two different d-c levels of bias are measured and subtracted.

Extremely stable d-c power is necessary for these bridges. No single bridge circuit or read-out seems to excel over the other in practice. In the high-precision circuits used by standardizing laboratories, there are many and varied designs. In one design, a constant-impedance attenuator is placed in series with the bridge so as to enable adjustment

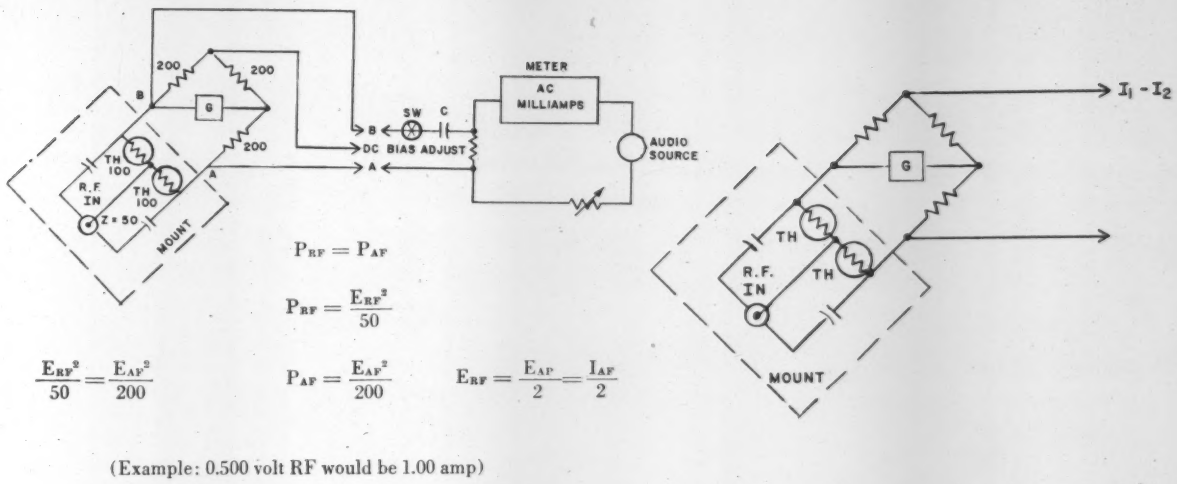


FIG. 6. MANUAL audio-substitution bridge.

FIG. 7. SUBTRACTIVE (DC substitution) circuit.

of bias current without affecting battery drain for best stability.

R-F power in d-c substitution systems is easily computed from:

$$P_{rf} = 1/4(I_1^2 - I_2^2)R$$

for the usual case of an equal arm bridge, where R is the bridge resistance, I_1 is the total bridge current *before* application of R-F power, and I_2 is the total bridge current *after* application of R-F power.

The source of trouble with the *d-c substitution bridge* is the term $(I_1^2 - I_2^2)$. For example: At RF levels on the order of 10 microwatts, I_1 might be 20.00000 milliampere, while I_2 might be 20.00100 milliampere. Measurements like these are usually beyond the practical range of commercial potentiometers. In other words, *subtractive d-c systems* usually require high-accuracy potentiometers, and definition is limited at low levels due to error in detecting and measuring small differences in two closely related high levels of voltage or current. (The reader is referred to a novel, recently patented *d-c substitution system*, patent U. S. #2,883,620, Selby, Alfred, Hudson, Berry.)

An adjustable d-c source can be used to bias the bridge to balance with the R-F power connected, then using audio power directly across the thermistors to regain balance when the R-F power is disconnected. This, in principle, is the audio substitution method used in Stoddart Aircraft Radio Company's power bridge. Most commercial bridges employ a self-balancing (except for "0" adjustment) variation of this principle, with a meter located in the audio circuit so as to read out substituted power directly. This method has some shortcomings, the most important of which are:

1. Interaction of the audio biasing power with the R-F power, if the latter is pulsed at a rate near the audio frequency, or if the two frequencies themselves are close (such as in the case of VLF R-F power). This problem is eliminated, of course, if the audio is manually substituted for the R-F power, as in the Stoddart bridge.
2. Quadrature errors from the capacitively-coupled audio power. These are known mathematically, however, and can be accounted for.
3. Nonequivalent effects due to unequal heating of the thermistors to RF and the relatively low-frequency audio power.

The audio substitution power is generally easy to measure. A highly stable d-c source is still required; stabilities on the order of 0.00001% for line, load, and temperature are not unusual requirements for bridges operating under 50 μwatts. Some clever self-balancing circuits and bridges are in existence today, but are relatively expensive—and resolution and sensitivity below 50 μwatts is still lacking. Some of this is due to the low sensitivity of the mounts used, of course.

It should be noted, however, that strictly from a theoretical standpoint, the *subtractive d-c method is inherently more accurate than the audio substitution system.*

Voltage Standards

Mention should be made of the recent development of laboratory voltage *standards*, typified by the Ballantine Laboratories Model 440 NBS Micropotentiometer (DC-900 MC, 40.0 microvolts to 400 millivolts), and Model 390 NBS A-T Voltmeter for higher voltages and frequencies. These are based on designs by Mr. Myron C. Selby and Mr. L. F. Behrent of NBS, Boulder, Colorado. The A-T Voltmeter is simply a piston attenuator in front of a micropotentiometer which consists of a calibrated wideband resistor and thermocouple for measuring current. They are excellent devices and NBS can furnish 3% (possibly better in near future) certification up to 1000 Mc. Various combinations of resistance units and thermocouple units are available for different voltage ranges. It is unfortunate that the output impedance is lower than 50 ohms (0.022

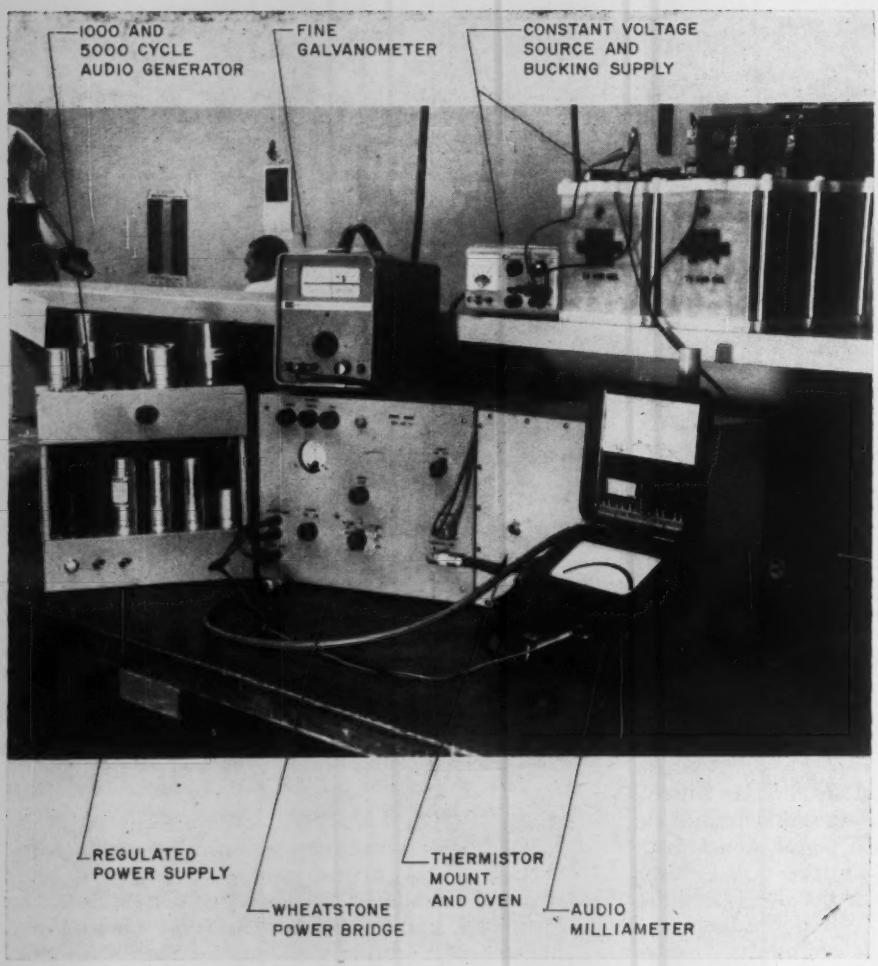


FIG. 8. EQUIPMENT set-up using special R-F power bridge to calibrate signal generator.

to 22 depending on unit). However, they remain the best voltage devices available at present.

Mounts

The R-F mount uses thermistors to measure the power of a signal.

Most high-quality, precision R-F mounts use two thermistors with two capacitors so connected as to be 50 ohms in and 200 ohms out. Mount problems involve skin effects of the thermistors, porosity of the silver plating, dielectric absorption, resistive losses in metal surfaces, etc. Typical well-designed mounts still have losses of near 5% at 3 kMc. To enable use at the lower frequencies, the capacitance of the coupling capacitors must be greatly increased. For example, a typical mount might require two 0.25-μfd capacitors to reach 100 kc. Naturally, these capacitors have residual inductances which cause them to resonate at one or more frequencies. Some development work has been done with the tantalytic capacitor; unfortunately, the resonant points are not stable. This is one reason why commercial chip bolometer and thermistor mounts are rated down to 10 Mc, which avoids use of the large capacitors necessary at lower frequencies.

Calibrating Signal Generators

Stoddart's method of calibrating signal generators (supplying known R-F voltages to its RFI equipment) is not unique, but the means of furnishing the end results are unusual. Briefly, Stoddart uses its own specially-designed R-F power bridge to calibrate signal generators (Fig. 8). These signal generators are carefully calibrated as to frequency, VSWR, harmonic content, and drift. They are completely overhauled at frequent intervals (90 days; sooner if required). Weekly spot checks on output are made with an R-F voltmeter that is carefully calibrated just before use by the power bridge. Daily checks are made by the operators by intercomparison. All generators have their line power turned on automatically several hours before the start of the work day. Each generator is furnished with a calibration card containing corrections for the frequency vernier dial, and for power output *at each increment of frequency used.*

Stoddart's signal generators also require a linear, repeatable attenuator system. The signal-generator attenuator always is used at least 15 db below maximum output, to reduce loading effects. Certified

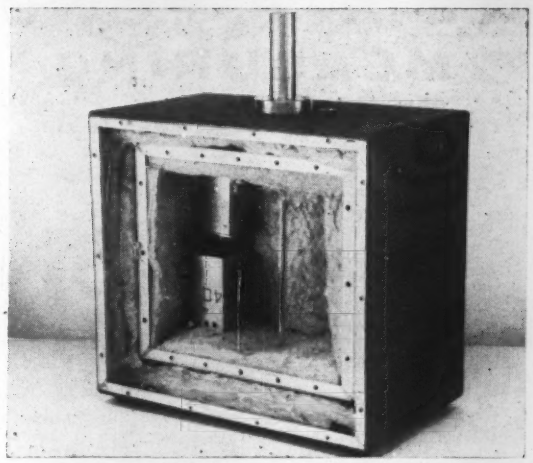


FIG. 9. THERMISTOR MOUNT in oven.

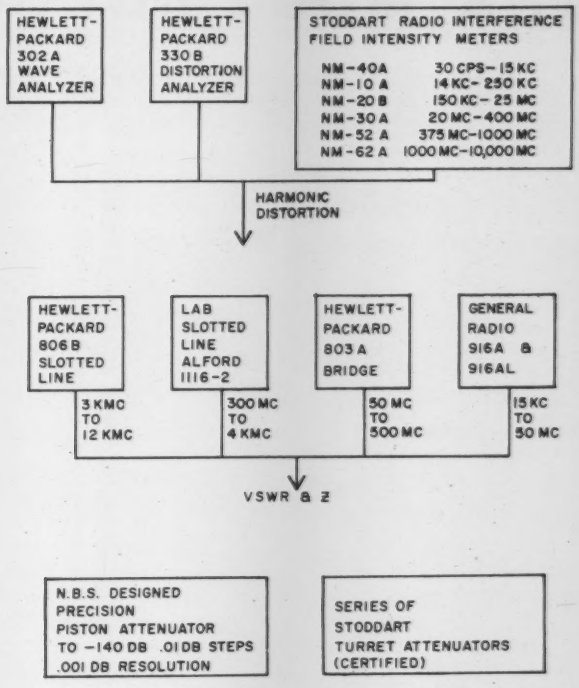

HEWLETT-PACKARD 302A WAVE ANALYZER
HEWLETT-PACKARD 330B DISTORTION ANALYZER
STODDART RADIO INTERFERENCE FIELD INTENSITY METERS
NM-40A 30 CPS-15 KC
NM-10A 14 KC-250 KC
NM-20B 150 KC-25 MC
NM-30A 20 MC-400 MC
NM-52A 375 MC-1000 MC
NM-62A 1000 MC-10,000 MC
HARMONIC DISTORTION
HEWLETT-PACKARD 806B SLOTTED LINE
LAB SLOTTED LINE ALFORD 1116-2
HEWLETT-PACKARD 803A BRIDGE
GENERAL RADIO 916A & 916AL
3 KMC TO 12 KMC
300 MC TO 4 KMC
50 MC TO 500 MC
15 KC TO 50 MC
VSWR & Z
N.B.S. DESIGNED PRECISION PISTON ATTENUATOR TO -140 DB .01 DB STEPS .001 DB RESOLUTION
SERIES OF STODDART TURRET ATTENUATORS (CERTIFIED)

FIG. 10. EQUIPMENT for measurement of harmonic distortion (top); middle shows equipment for VSWR and Z; bottom shows reference attenuators.

turret attenuators and an NBS-designed precision piston attenuator are standard references.

At present, Stoddart has in daily use a dual thermistor bridge covering the range of 4 kc to 2000 Mc, without corrections due to resonances, etc. Residual VSWR is held below 1.13 at 2000 Mc. The basic mount covers 2 Mc - 2000 Mc (higher to 5000 Mc with an increase in VSWR), but an ingenious circuit allows coverage down to 4 kc. This is perfectly stable, and is not subject to long-term change. Sensitivity of the system is such that resolution in the 5-10 microwatt region is better than ¼%. One of the features of this design which allows measurements of great accuracy at low levels is the ultra-stable oven which houses the thermistor mount (Figure 9). Stability is greater than 0.04°F in the oven, with even greater stability inside the mount. The high limit of direct measurement is near 20 milliwatts.

High-frequency signal generators (below 2000 Mc) are calibrated at a level of 25 kilomicrovolts (about 12½ microwatts or —19 dbm), and microwave generators are calibrated at 50 microwatts.

Because receivers respond to narrowband voltages, while the thermistor "sees" wideband power, a series of low-pass filters, accurately calibrated, are used when calibrating the generators.

Problems still remain in power bridges, mostly in the mounts, although d-c supplies with greater than 0.00005% stability are almost impossible to realize. Certification of mounts by NBS is, according to our information unavailable below 9000 Mc; even here only the waveguide type is certified. Losses and non-repeatability of coaxial connectors (such as the type "N") at frequencies above 4000 Mc are such a problem that waveguide seems the only answer at microwave frequencies. However, it will be helpful to industry to have coaxial mounts certified below 5000 Mc as soon as is practicable.

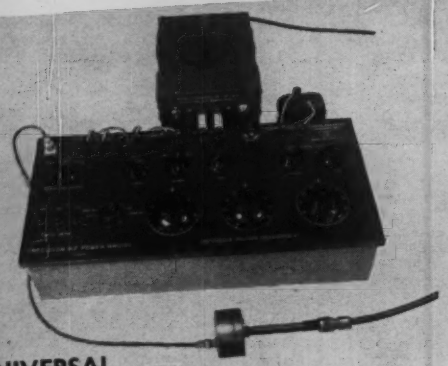
It is of interest to note the magnitude of error for a given VSWR depending on whether a voltage or a power measurement is made. For example, assume a known 50.00-ohm signal source to be working into mismatched loads of 1.2/1; 1.5/1; 1.7/1; 2.0/1 VSWR, respectively. The load could be a receiver, thermistor mounts, etc. The resulting voltage errors are 9.09%, 20.0%, 25.9%, and 33.3%, respectively, in the load. However, the corresponding power errors in the load are 0.7%, 4.0%, 6.73%, 11.1%, respectively. Note: this is load error and not to be confused with the actual error in generator calibration. The generator is actually putting out the wrong voltage due to the improper loading. Voltage error of the generator calibration would be 0.355%, 2.07%, 3.57%, 6.1% respectively, for the given VSWR in the mount.

Fig. 10 shows a typical traceability chart for harmonic distortion, VSWR and impedance, and attenuation, similar to that used at Stoddart.

References

1. T. F. Haddock, "Introduction to Radio Astronomy", *I.R.E. Transactions*, Jan., 1958.
2. Albert Van der Ziel, *Noise*, Prentice-Hall, 1954.
3. Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pennsylvania, Investigation of the Measurement of Radio Interference, Progress Report No. 53.
4. Glenn F. Engen, "A Self-Balancing Direct Current Bridge for Accurate Bolometric Power Measurements, "*Journal Research NBS*, Vol. 59, page 101, 1957, RP .2776.
5. R. W. Beatty and Frank Reggia, "Improved Method of Measuring Efficiencies of Ultra-High-Frequency and Microwave Bolometer Mounts," *Journal Research NBS*, Vol. 54, 1955, RP 2594.

THE MOST ACCURATE R. F. POWER MEASURING SYSTEMS



UNIVERSAL PRECISION DC BRIDGE — Model PB-1

The Model PB-1 is a DC substitution bolometer bridge capable of accuracies to 0.1% in the measurement of substituted DC power. It is used in standards laboratories which require the highest attainable accuracy in high frequency power measurements. It is also used in the transfer of calibration factors from one bolometer mount to another. When used for very precise measurement of insertion loss up to about 10 db, this measurement becomes directly traceable to DC resistance and voltage standards.

SELF-CONTAINED DC THERMISTOR BRIDGES

For 1.0 and 10.0 Milliwatts

Models TB-2A and TB-3

Uses:

- Calibration of output level of standard signal generators
- Calibration of bolometer mounts
- Power monitor in precision measurements requiring constant power level
- Establishing known R. F. power levels for calibration of power meters and other power sensitive devices

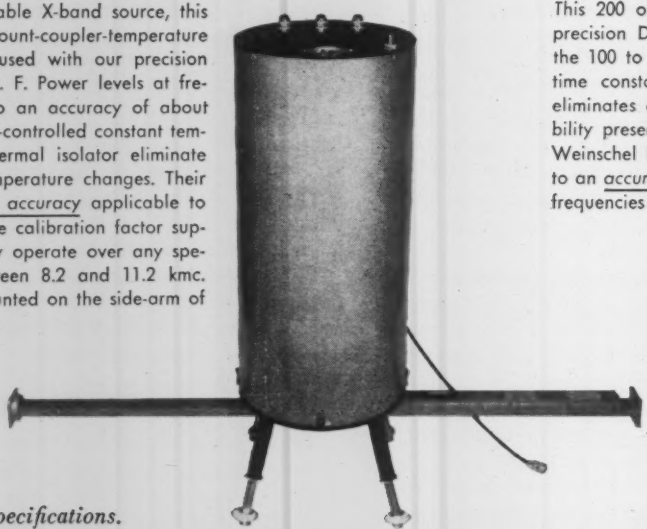
Specifications:

R. F. Power Level: TB-2A—1.00 mW/TB-3—10.0 mW
Accuracy of Substituted DC Power: ± 0.15%
Calibration Factor Range: 0.85 to 1.05, adjustable in steps of 0.01.

CALIBRATED BOLOMETER MOUNTS

Models 811, 813 and 815 X-Band Power Standard

In combination with a stable X-band source, this 200 ohm thermistor mount-coupler-temperature chamber combination is used with our precision DC bridges to establish R. F. Power levels at frequencies in the X-band to an accuracy of about 1.1%. The thermostatically-controlled constant temperature chamber and thermal isolator eliminate the effects of ambient temperature changes. Their stability preserves the 1% accuracy applicable to the NBS test report for the calibration factor supplied with each unit. They operate over any specified 200 mc band between 8.2 and 11.2 kmc. They are permanently mounted on the side-arm of a 3 db directional coupler.



Model 675-A Coaxial Thermistor Mount

This 200 ohm thermistor mount is used with our precision DC bridges to measure R. F. power, in the 100 to 4000 mc range. The very long thermal time constant of the bolometer mount virtually eliminates ambient temperature changes. This stability preserves the *calibration factor* supplied by Weinschel Engineering at 400, 1000 and 1500 mc to an accuracy of 2%. Calibration factors at other frequencies are supplied on special order.

Write for complete specifications.

PRECISION MICROWAVE MEASUREMENT COMPONENTS, INSTRUMENTS AND SYSTEMS

WEINSCHEL

ENGINEERING COMPANY KENSINGTON, MARYLAND • Phone: LOckwood 4-0121 • TWX: KENS 446
In CALIFORNIA • 631 Wilshire Boulevard, Santa Monica • TWX: SMON 7185

CIRCLE 86 ON READER-SERVICE CARD

Standard on Shock and Vibration

RAYMOND R. BOUCHÉ

A NEW AMERICAN STANDARD—American Standard Methods for the Calibration of Shock and Vibration Pickups S2.2-1959—describes most calibration methods in use today. These cover three basic types—constant acceleration, sinusoidal motion, and shock motion. The ranges and accuracies are given in the table. In addition to the standard calibration methods included in the main body of the standard, others that have been introduced that are more limited in use or that are less accurate are included in the appendix. It is expected that some of the methods in the appendix will be moved to the main body of the standard as their accuracy and usefulness become more firmly established.

Constant-Acceleration Calibrations

Constant-acceleration calibration methods included in the standard are the *tilting support* and the *centrifuge*, the two calibration methods that are the most accurate and the least difficult to perform. The most important transducers calibrated by these two methods are those used to measure low frequency or nearly static acceleration.

The first method makes use of a tilting support to position accurately the acceleration pickup in the earth's gravitational field. As tilting supports can be carefully constructed, it should be possible to achieve calibration accuracies better than those indicated in the table. In the second method, the accelerometer is placed off-center on a centrifuge. This method is widely used for performing calibrations at constant accelerations greater than that of gravity.

Sinusoidal Motion Calibration

Absolute calibrations are performed accurately on rectilinear *electrodynamic calibrators* which produce sinusoidal motion throughout a wide range of frequencies. The reciprocity calibration of electrodynamic calibrators is described prominently in the standard because of the high accuracy obtainable over a wide range of frequencies. As this method requires a series of tedious and time-consuming tests, it usually is performed only in the primary standards laboratory.

The *physical pendulum* produces nearly sinusoidal motion that slowly decays due to air resistance and

This appeared originally in *The Magazine of Standards* and is reprinted through the courtesy of the American Standards Association, Inc. It also appeared in the *Endevco Quarterly*.

Table—Estimated Ranges and Errors of Standard Calibration Methods

Method	Tilting support	Centrifuge	Rectilinear electrodynamic calibrator	Physical pendulum	Ballistic pendulum
Input	constant acceleration	constant acceleration	sinusoidal acceleration, velocity, or displacement	transient acceleration, velocity, or displacement	transient velocity or acceleration
Amplitude	−g to +g	0-60,000g	0-25g 0-50 in./sec 0-0.5 inch	0-10g 0-100 in./sec	2500g
Frequency	0	0	8-2000 cps	0.5 to 5 cps	—
Duration of pulse	—	—	—	—	0.00035-0.001 sec
Maximum weight of pickup	10 lb	100 lb at 100g to 1 lb at 60,000g	2 lb	2 lb	1 lb
Estimated errors of input	±0.0003g	±1%	±1% (8-900 cps) ±2% (900-2000 cps)	±2%	±5%

other losses. Although inherently an accurate calibration tool, it is limited to a small frequency range and, therefore, few calibration laboratories make use of it.

Shock Motion Calibration

The *ballistic pendulum* is a basic tool used for performing absolute calibrations under shock motions. Although accelerometers generally are calibrated by a method using sinusoidal motion, accelerometers used to measure shock motion should also be calibrated on a ballistic pendulum in order to subject the pickup to short-duration pulses. This method provides a particularly severe test of the accelerometer's freedom from spurious response due to excitation of its natural frequency.

Comparison Methods

Although the comparison method is a relative calibration method, it is accurate and widely used; therefore, it is also included in the main body of the standard. After a transducer is calibrated by one or more of the above-mentioned standard methods, it may be used to calibrate another, simply by comparing the output of the calibrated instrument with that of the one being calibrated. Both transducers are mounted to a surface or fixture subjected to the desired constant acceleration, sinusoidal motion, or shock motion. Most frequently, comparison calibrations will be performed on exciters producing sinusoidal motion. To accomplish this it is necessary to maintain vibration exciters which produce sinusoidal motion free of distortion and transverse motion, and to use care to design adequate fixtures.

Optical Methods

The two most important methods described in the appendix to the standard are the *optical direct viewing* and *interferometric methods*. Direct-viewing calibrations with a microscope can be easily performed with errors as small as $\pm 1\%$. This method is used widely; it is limited, however, to large displacement amplitudes of vibration and is usually used only at frequencies up to about 100 cycles per second. The fringe-disappearance interferometric method is receiving increased recognition because it is being performed with estimated errors of several percent at frequencies up to 10,000 cycles per second and higher. It is usually used to perform calibrations at displacement amplitudes of 4 microinches; therefore, it is not used at low frequencies.

Conclusion

The new American Standard provides information concerning all calibration methods and will be a useful tool for all shock and vibration laboratories. Many laboratories will use the comparison method to calibrate accelerometers over a wide frequency range. The secondary vibration standard used in the comparison method is calibrated with reference to one of the absolute methods. The National Bureau of Standards recently established a service for calibrating secondary vibration standards.

It is important to calibrate accelerometers on a regular basis commensurate with their use. After a pickup is subjected to rough handling, after it has undergone severe vibrations and shock motions at high frequencies and accelerations, and before it is used to measure the vibration of important test structures, recalibration should be a matter of routine.

for your library

WEIGHT MEASUREMENT & CONTROL

edited by Milton Aronson. This definitive practical text on weight instrumentation begins with a survey of fundamentals, progresses through basic weighing techniques, typical applications, and typical commercial equipment. Paper, 78 pages, 1961. ..... **$2.00**

ELECTRONIC CIRCUITRY FOR INSTRUMENTS AND EQUIPMENT

by Milton H. Aronson . . . a complete home-study text and course, with 458 multiple-choice home-study test items on basic electronic circuitry for instruments, communications, TV, laboratory apparatus, and military equipment. First edition was a complete sell-out. Third edition revised and up-to-dated. paper, 312 pages illustrated **$2.00**

STRAIN GAGE INSTRUMENTATION

edited by Milton Aronson and Robert C. Nelson ". . . a practical text . . . covers fundamentals, basic bridge circuits, typical applications, and surveys typical commercial instruments which use or are used with strain gages." 104 pages plus vi, 1958, illustrated, company index, author index, subject index **$2.00**

PROCESS CONTROL

by A. J. Young, Head of the Central Instrument Laboratory, Imperial Chemical Industries, Ltd. ". . . a MUST for all men who have to do with the automatic control of industrial processes; combines the practical "how" and the theoretical "why." 1955 cloth, 134 pages, illustrated **$2.00**

INSTRUMENTS PUBLISHING CO., INC.
845 RIDGE AVE., PITTSBURGH 12, PA.

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

DISTILLATION COLUMN CONTROL BY CONVENTIONAL PNEUMATIC SYSTEM

The basic unit in many refining processes is a distillation column. When crude oil is the feed, the products (overhead and at various levels) include straight-run gasoline, lighting naphtha, cleaning solvent, first-grade burner fuels, diesel engine fuel, and industrial diesel fuel, etc. The material from the bottom of the column (bottom-products or reduced crude), if not further processed is sold as bunker fuel.

On the distillation column shown, there are seven "basic" variables under control:

(1) Feed rate.
(2) Feed temperature.
(3) Column temperature.
(4) Column pressure.
(5) Reflux flow rate.
(6) Product outflow rate.
(7) Bottom-product outflow rate.

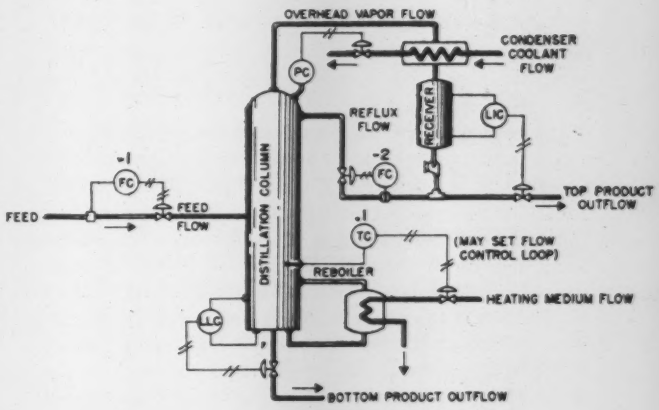
An eighth variable—product composition—also can be controlled. Among these variables, column temperature, column pressure, and reflux flow are considered the "fundamental" variables, with control of the other four serving to maintain stable conditions.

The pneumatic system shown is a typical arrangement. (Variations of this instrumentation include cascading of several variables, the use of analytical instruments in the control loop, use of computers to control the process, etc.)

Feed rate depends on column size, efficiency, etc. Thus the control point of flow controller FC-1 is an empirical value. The pneumatic controller is usually recording, and receives its measuring impulse from an orifice in the feed line. Its control modes are proportional and reset because constant feed rate is desirable for efficient distillation-column operation.

Temperature of feed (control loop is not shown) usually is controlled by steam admitted to a feed preheater before the crude is fed to the column. A temperature controller, usually of the recording type, senses feed temperature by a vapor-tension bulb in the feed line near the column. Mode of control required in this loop is proportional plus reset plus rate.

Column temperature is controlled by control of steam to the reboiler. A temperature controller (TC-1), usually of the recording variety, senses temperature of the distillate in the column near the reboiler inlet and controls the flow of heating medium (steam) through the reboiler. Proportional plus reset plus rate are required also in TC-1 for good control. This system is designed for applications where a constant steam supply is available.



Column pressure usually is controlled in an indirect way, via the overhead-vapor condenser. A pressure (recording) controller (PC) senses the pressure in the column near the top and controls the flow rate of the coolant through the condenser, which determines the amount of condensation, and hence the overhead pressure. Good control requires proportional-plus-reset-plus-rate mode here also.

Reflux flow rate is determined by a (recording) flow controller (FC-2) with an orifice in the line to sense the flow rate. FC-2 also requires proportional and reset modes of control.

Top product outflow rate is controlled via an indicating instrument (LIC) from the level of the receiver. An averaging differential-type instrument is the preferred type for this application. Control mode of LIC is proportional.

Bottom-Product outflow is usually controlled from the level in the bottom of the column, via a liquid-level controller (LLC), which usually also records the flow. LLC, like LIC, is usually a differential-pressure-type instrument, and has proportional mode of control.

Equipment used: Two flow controllers; two temperature controllers; pressure controller; liquid-level indicating controller; liquid-level recording controller. All controllers in system shown are Model 40, equipped with control mechanisms as described (Model 53-58 Consotrol instruments may also be used). Seven control valves are needed. (Six are shown; seventh is in feed-temperature steam line).

Source: Foxboro Company, Mass.; also "Dynamic Testing of Industrial Instruments" by Allan R. Catheron.

PELLETIZING-FURNACE BLAST-AIR TEMPERATURE CONTROL

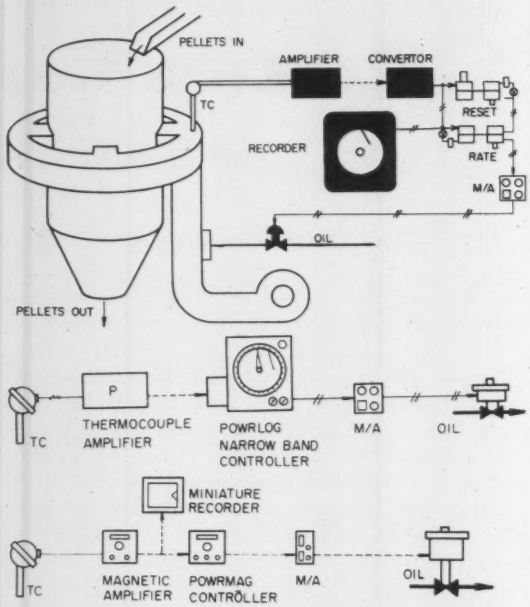
The ratio totalizers operate on the force-balance principle, combining input-signal pressures and spring forces to produce a single output signal pressure. TC is a thermocouple. The pneumatic signal from the electro-pneumatic converter (EPO) is fed both to the upper totalizer and to the lower totalizer. While the upper totalizer produces proportional-band and reset action the lower one furnishes the rate control mode. These actions are achieved by needle-valves and volume chambers placed ahead of the totalizer chambers, as shown.

Equipment: Thermocouple, Type K; PowrAmp d-c amplifier; electropneumatic converter; two ratio totalizers, Model 51; M/A manual-automatic control station; recorder.

The control of the temperature of the air blown into a pelletizing furnace to promote combustion and the sintering of the pellets is a critical part of this operation.

The furnace resembles a blast furnace; the pellets being fed in at the top. Hot air is blown through tuyeres near the bottom of the furnace. If the air is allowed to get too hot, the pellets fuse and form a solid mass instead of discrete nodules. The optimum method of maintaining temperatures limits is to suppress the range of temperature control. The system illustrated uses a chart with only 2200° - 2300°F range, controlling at 2250°F.

This close control (limits of 2°F) required proportional, rate and reset action, obtained from "totalizers," which also furnish the range suppression.



Two alternate systems also are shown. The first is a PowrLog recorder with narrow-band control system and a pneumatic output. The second uses a magnetic-amplifier followed by a PowrMag (magnetic-amplifier-type) controller with proportional, reset and rate actions.

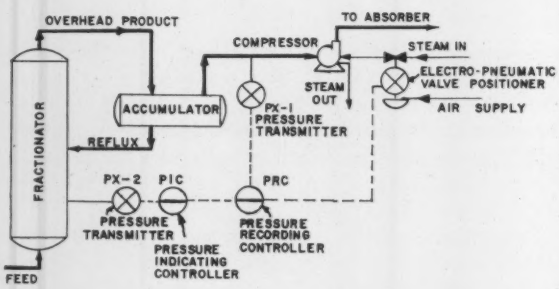
Source: Hagan Chemicals & Controls, Inc., Pittsburgh, Pa.; also "Behind the Panel," No. 14.

FRACTIONATING COLUMN INSTRUMENTATION BY ELECTRONIC SYSTEM

In a fractionator column, pressure can be controlled accurately by a cascade system in which a pressure controller (PRC) receives its primary signal from a connection in the output gas line (through pressure transmitter PX-1) and has its control point reset by a second signal from a pressure transmitter (PX-2) in the fractionator.

The compressor, driven by a steam turbine, sucks the gas out of the accumulator, compresses it, and delivers it to the absorber for further processing. The accumulator receives the overhead product from the column. Thus pressure in the column is controlled by the amount of gas removed from the accumulator. This amount is determined by the speed of the turbine.

Steam flow to the turbine is controlled by a control valve which is the final element in the system. The control valve receives a transmitted signal from the pressure recorder-controller PRC, having proportional and reset modes of control. The set point of PRC is determined by a pressure indicating controller PIC with proportional and reset modes of control. This controller senses fractionator pressure relayed to the instrument by pressure transmitter (PX-2) and resets the control point of PRC by an electrical signal of 1.0 to



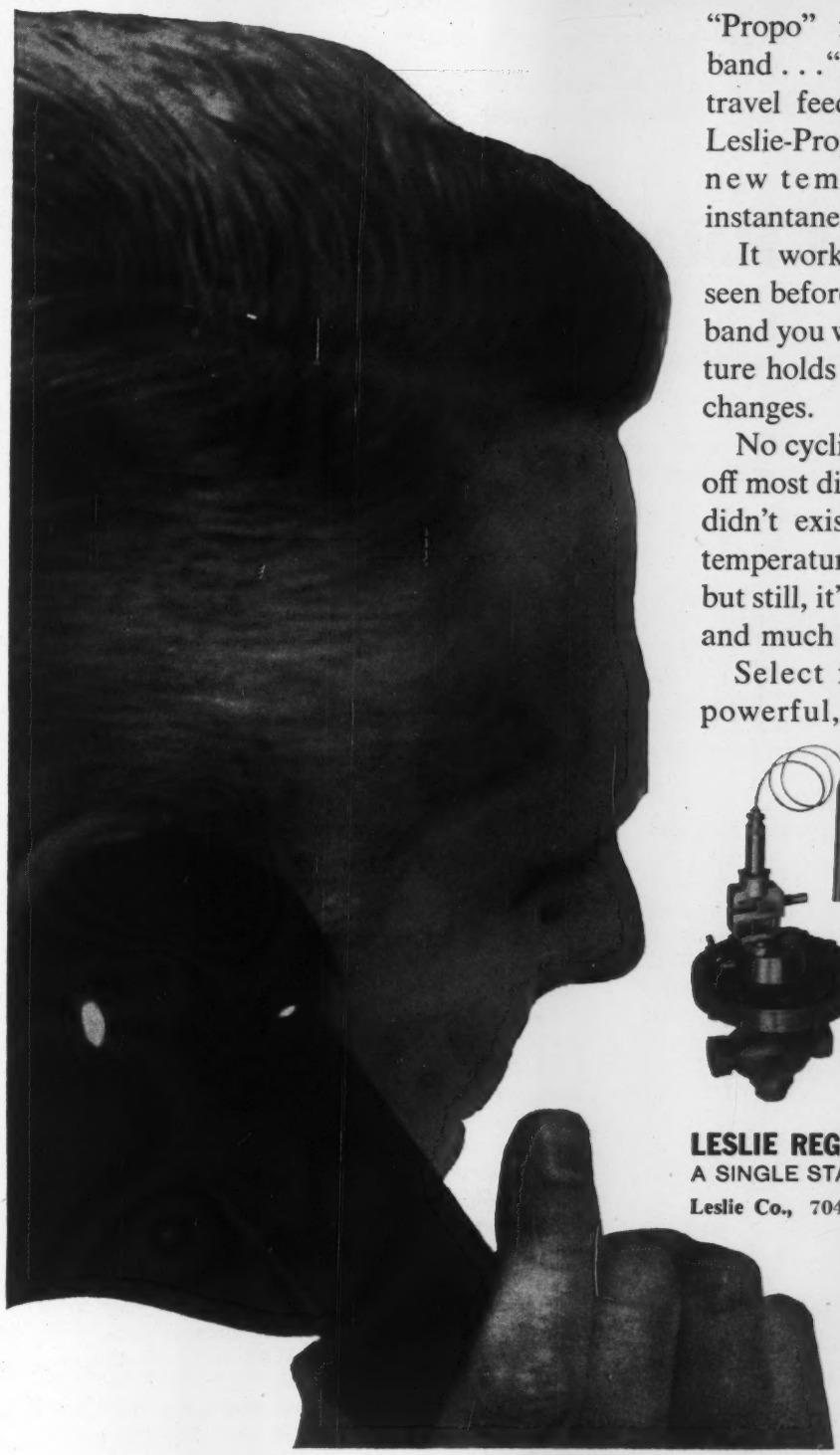
5.0 ma dc. The output signal (1.0 to 5.0 ma dc) of PRC is sent to the electropneumatic valve positioner for final element control.

Equipment used: Microsen pressure recording controller, Type C112L; Microsen pressure indicating controller, Type C122L; Type 145, Microsen pressure transmitter; single-seated control valve with Microsen electro-pneumatic valve positioner Type 132R.

Source: Robertshaw-Fulton Controls Co., Aeronautical and Instruments Division, Anaheim, Calif.

The best name we can think of is

PROPOMATIC



"Propo" for adjustable proportional band . . . "Matic" for automatic valve travel feedback. Put them together — Leslie-PropoMatic® — and you get the new temperature regulator for instantaneous-type heater service.

It works like nothing you've ever seen before. Set the dial for the control band you want, and that's all. Temperature holds steady, even under fast load changes.

No cycling. It's stable! And it shrugs off most dirty steam problems as if they didn't exist. In *effect* it's a pressure-temperature cascaded *control system* — but still, it's a *regulator* — easy to install, and much less in initial cost!

Select from 50F, 100F or 200F powerful, interchangeable thermo elements. Bronze or iron, ½ to 4″, screwed or flanged ends. PropoMatics handle inlet pressures to 150 psi, temperatures as high as 500F.

Engineering Data Bulletin 611 has all the data on PropoMatics. Send for it — no obligation.

LESLIE REGULATORS AND CONTROLLERS
A SINGLE STANDARD OF QUALITY SINCE 1900
Leslie Co., 704 Grant Ave., Lyndhurst, New Jersey

LESLIE

CIRCLE 212 ON READER-SERVICE CARD

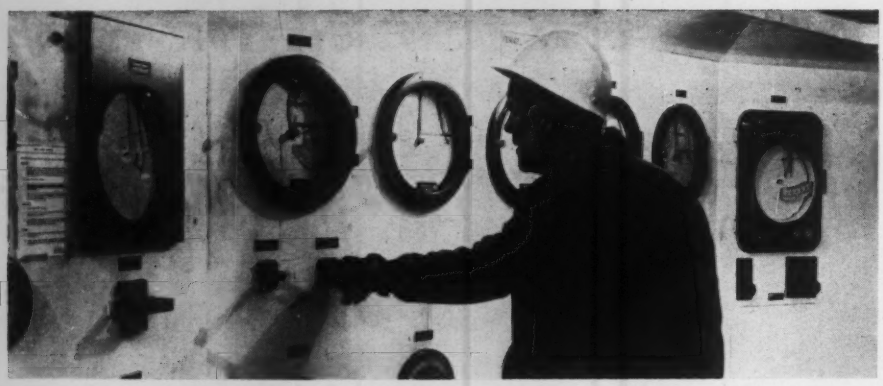


FIG. 1. CONTROL panel for one furnace.

Variable-Area Meter for Viscous Service

PHILIP O. DES MARAIS, Brooks Instrument Co., Inc.

Variable-area flowmeters (rotameters) measure #6 Bunker C fuel oil flow for twenty-four open-hearth furnace combustion control systems.

EARLY in 1959, the Fennel Corporation, Design Engineers and Contractors, and the Instrument Engineers at Inland Steel, Indiana Harbor Plant, were faced with the problem of metering high-viscosity #6 Bunker C fuel oil to the twenty-four open-hearth furnaces in Open Hearth #2. This was a part of a modernization program to replace the existing combustion control systems. Mill capacity potential was studied with furnace combustion control of coke-oven gas, natural gas, and Bunker C fuel oil.

Important considerations for selection of the fuel flow instruments were—(1) initial installation cost, (2) need for a linear 3-15 psig pneumatic signal, (3) a minimum of moving parts in the flow lines, (4) elimination of possible stagnant areas where fuel could settle or crystallize, (5) need for consistent ±2% accuracy, (6) a maximum pressure drop of 36" W.C. across the instrument, and (7) Bunker C flow-rate design requirement of 80-800 gallons per hour.

The Bunker C fuel oil originates from large storage tanks located throughout the mill. This 150,000-BTU-rated fuel is pre-heated to 225-230°F, at which temperature the viscosity of the liquid* is 135 SSU ±10 SSU, and has a specific gravity of 0.963. The fuel is pumped at 220 psig to the 24 open-hearth furnaces, which have identical combustion control systems (Fig. 1).

Combustion Control System

The control system shown in Fig. 2 maintains fuel oil flow at a set point derived from a master furnace BTU-control in the following manner:

A master-control BTU setter on the control panel shown in Fig. 1 (upper right in Fig. 2) is a slidewire calibrated from 0-120 million BTU. The BTU setter sends a signal to a Natural-Gas Flow Control, where an operator manually sets the percent of total BTU desired in gas. Gas flow then is subtracted from the total BTU setting. The remaining signal is the demand for Bunker C fuel oil and becomes the set point signal shown at bottom of Fig. 2.

Fuel oil flow is measured by an indicating pneumatic-transmitting rotameter (Brooks 3611-MPTX-50), which delivers a 4.2-15-psig signal. The signal is linear with flow in the range from 10-100% of flow, and accuracy is within ±2% of maximum flow. A 4½" direct-reading scale on the transmitter (Fig. 3) is graduated for a range of 80-800 gph. The normal average flow is 150-250 gph of Bunker C fuel oil.

The method for translating the linear motion of the metering float into rotary motion (and then into a pneumatic signal) consists of a magnetic iron strip formed into a helix (Fig. 3) and encapsulated in a non-magnetic stainless steel tube. The helix assembly is located parallel and adjacent to the

*Rotameters have been used for liquids having a viscosity as low as 0.3 centistoke and as high as 2,000 centistokes. Although the standard guaranteed accuracy is ±2%, they can be furnished for ±1%. Thruflow meters with maximum capacities as high as 600 gallons per minute of water equivalent have been built (there is no upper limit). A 10:1 flow range is standard.

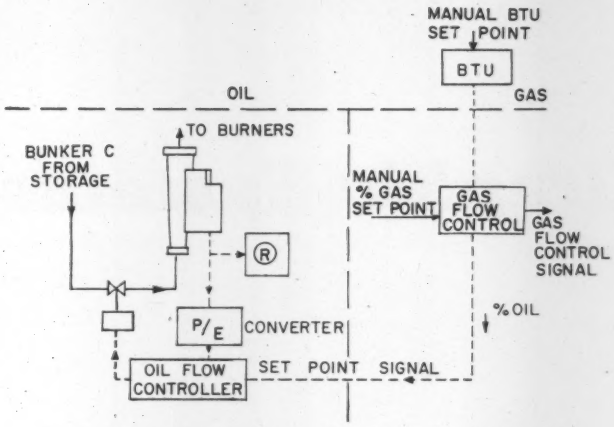


FIG. 2. BUNKER C fuel system for an open-hearth furnace.

rotameter metering tube. The metering float has a magnet imbedded in it, and the edge of the helix is constantly attracted to the magnet, converting linear motion to a rotary motion. A pointer attached to the helix indicates flow on a curved scale.

The pneumatic signal from the rotameter is converted to a voltage signal which then is fed to the oil-flow controller (bottom left in Fig. 2). This controller actuates the flow control valve to maintain the proper flow of fuel oil to balance the set point signal (from the natural-gas/oil ratio controller).

Each open hearth has two burners, one on each end of the furnace. Firing reverses every ten minutes from one burner to the other. This presents a heavy working load on the single rotameter because flow shuts off and the rotameter float drops to zero until the change to the other burner is made. Then the flow control valve re-opens and the rotameter float rises. These severe operating conditions have caused no adverse effects on the operation of the rotameter or any of the control equipment.

The system used before this system was installed was a manually-operated system using a positive-displacement-type meter with an integrator for fuel flow. The rotameter was found to maintain sustained accuracy with less maintenance required than that for the integrating meters. The integrating meters were removed from service, and present practice is to determine fuel oil consumption by deducting the integrated gas flow from the BTU consumption. This procedure has been found more practical and more accurate than was the integrating meter previously used. It also is less expensive than adding integrators to each rotameter in the 24 systems.

The system was designed initially for handling 80-800 gph of Bunker C fuel oil. As actual operation is at 150-250 gph, a lighter float could be used in the rotameters to reduce the effective flow range.

The entire open-hearth combustion control system has been operating satisfactorily; the rotameters have maintained the calibrated ±2% accuracy for more than a year.

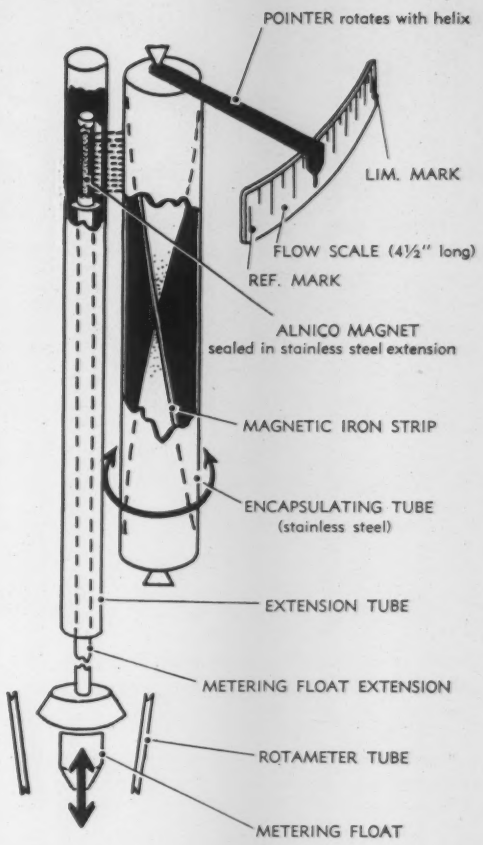


FIG. 3. EDGE of helix in magnetic position converter is attracted to magnet in float. Helix rotates as float moves up and down, thus indicating float position.

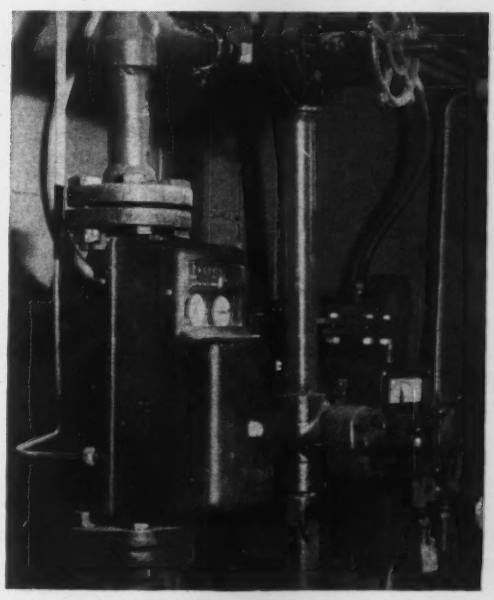


FIG. 4. ROTAMETER flowmeter in operation on Bunker C fuel oil.

Graphic Systems

Design techniques and materials contribute to effective control system graphic displays.

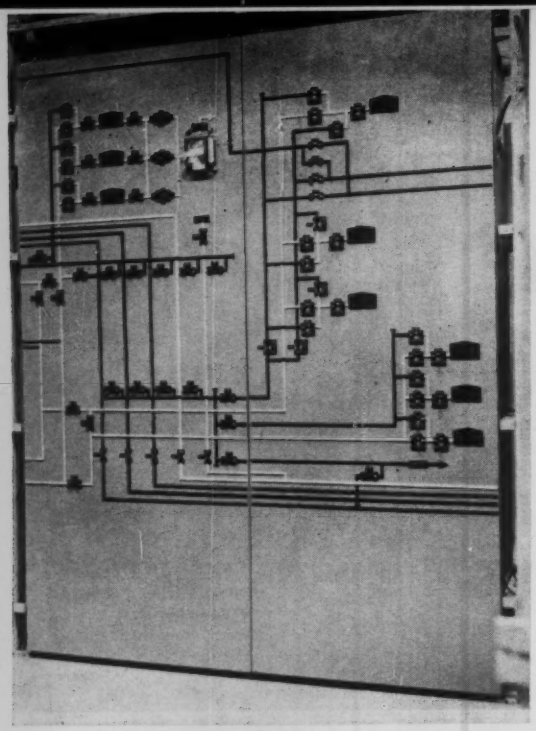


FIG. 1. A FLOW-PLAN of the process to be controlled is made up of simplified outline shapes and forms (graphic symbols), which are arranged to depict the actual process plant layout. Control instrumentation is located within the schematic, in the same relationship as it is actually in the plant.

EVER-INCREASING complexities of centralized control systems emphasize the importance of graphic panels. These permit an operator to see a complete system, lines of flow, location of instrumentation, and cause-and-effect relationship of various conditions in the system. This is possible by providing a centralized control panel on which is mounted a picture schematic of the entire system. Instruments are located in their proper position within this picture. This schematic is made up of symbols or simplified outlines and shapes for each major piece of equipment. Interconnecting lines are added to indicate flow, pipelines, or electrical buss. Instrumentation is coded to differentiate at a glance between pressure, temperature, flow, level, quantity, etc. (Fig. 1).

Single-Plane Systems

Where low cost or frequent revisions and modifications are significant factors, a simple, functional flat graphic system is employed. This type of graphic display can be painted directly on the front face of a panelboard, or on a sub-panel which is subsequently mounted onto the panelboard. However, straight, sharp lines are difficult to obtain with hand painting or masking. Silk screening overcomes this drawback, but preparing a screen for a single imprint becomes prohibitively costly. Necessary field modifications and additions to painted systems frequently must be performed by unskilled service personnel, often with unfortunate results. Further, once in service inevitable chipping and scratching of the painted surface will result in a control panel that becomes an eyesore.

The availability of dimensionally-stable, chemically-inert, pigmented or clear *plastic sheeting* provides a more suitable material of fabrication. Semi-rigid sheet of 0.015″ to 0.030″ thickness is employed most often. This sheeting provides desirable rigidity, important in assembling finished components to a panelboard surface. Process equipment (tanks, towers, motors, condensers, valves, pumps, etc.) and related instrumentation are reduced to circles, rectangles or simple shapes. These simplified shapes (graphic symbols) are formed from plastic sheet materials by special equipment specifically designed to produce clean, sharp shapes. (Fig. 2).

Colors are used for component and function identification. Color can be used to underscore outstanding features and functions, point out alarm and signal points, and identify flow patterns. Color schemes should be prepared by an art group to insure compatibility and preserve over-all aesthetic values.

When six or seven colors comprise a system, pigmented stock is employed. Since pigmented sheet materials are usually highly polished, graphic component specifications should call for a surface treatment to produce the more-desired satin finish, which eliminates glare in a finished installation and also masks minor scratches accumulated in forming.

If more than seven colors are required, paint finishes are employed over clear plastic. The paint finishes must be of the type which will bond with the materials to which they are applied.

Engraving is used widely for component identification or function legends. Information can be engraved directly into any plastic graphic symbol.

Techniques

ALLEN DEVRISHIAN
Devco Engineering Incorporated
Caldwell, N. J.

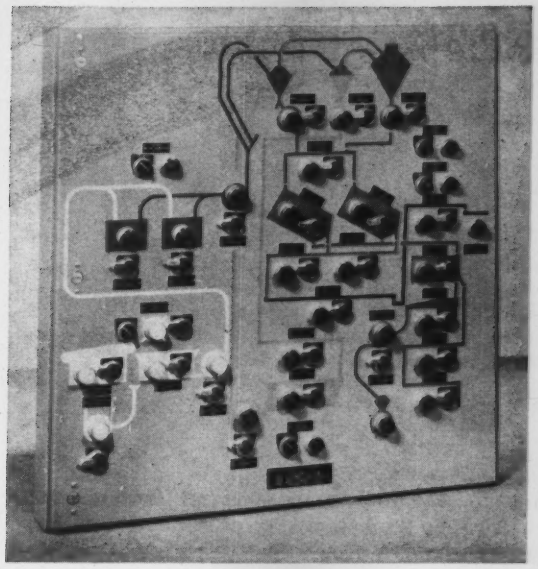


FIG. 2. LOW-COST easily-modified graphic displays can be fabricated from pigmented plastic sheeting with pressure-sensitive adhesive mounting. Both initial assembly and field modification can be performed by unskilled personnel. Final appearance is sharp, clean, and durable.

On more complex equipment symbols, internal features (such as conveyors, motors, flowline or instrumentation) are indicated by engravings which are usually inlaid with a contrasting color pigment to provide clarity and attractive appearance.

For maximum scratch resistance, protective overlays of clear Mylar can be applied over finished graphic components. However, the additional expense could be justified only in cases where severe in-use abrasion is anticipated.

As one of the design criteria of this system is ease of modification, mounting of flat-type graphic symbols onto the panelboard is achieved by use of pressure-sensitive adhesives. Sheet plastic materials used in the fabrication of graphic symbols are prepared with a pressure-sensitive adhesive backing.

The various graphic components are mounted by stripping the adhesive protective covering and pressing the symbols into place on the panelboard surface. All process equipment and instrumentation designation symbols are mounted in place first. Flowline or electrical buss lines are then added. Bends and corners in the flowline are made either by mitered joints or by separate elbow pieces. Directional arrows are inserted into the flowline runs as required. Joints, where two flow line components meet, are made by butting tight or, more simply, by leaving a 1/16″ to 3/32″ gap between sections. This latter method eliminates the need for precise matching and allows for fabrication tolerances (Fig. 3).

A complete system, while actually flat, stands out from the panelboard surface because of its thickness. Lines are sharp and clean, and the overall result is attractive. Revisions and modifications can be performed readily in the field by unskilled labor. Obsolete components can be stripped off, and replacements simply pressed into place, all at moderate cost.

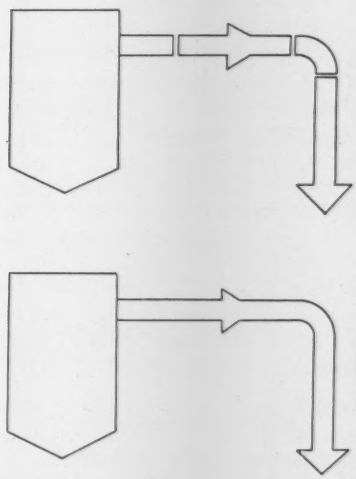


FIG. 3. JOINTS (where two flowline components meet) are made by butting tight or, more simply, by leaving a 1/16" gap between sections. This latter method eliminates matching errors due to fabrication tolerances.

Three-Dimensional Systems

For more complex systems, human engineering becomes a design factor. The picture must be made easy to read from all directions. This need is met by three-dimensional, raised graphic components. All graphic symbols are fabricated from sheet stock of various materials and thickness. By varying thickness, certain key features are made outstand-

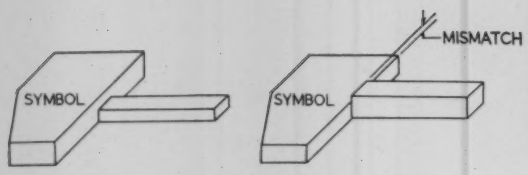


FIG. 4. UNAVOIDABLE tolerances in thickness of plastic sheet stock can cause mismatch where symbols and flowline components are joined. This can be avoided by specifying symbols as 1/16" to 1/8" thicker than interconnecting flowline. Appearance is improved and fitting eliminated.

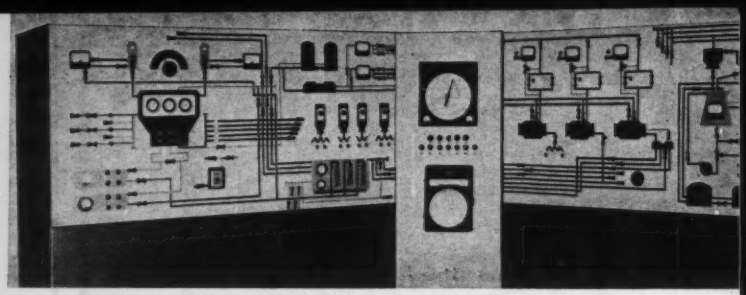


FIG. 5. ASSEMBLY procedure is to mount equipment and instrumentation designation symbols first. Interconnecting flowline then is added. With thermoplastic flowline materials, bends and corners are formed by application of heat and pressure. Mitered corners are employed widely.

ing. In addition to the primary instrumentation clarification function, three-dimensional raised graphic systems are distinctive.

A satisfactory arrangement can be realized by specifying all process equipment and instrument symbols as 3/16" thick, and all process flowlines or electrical buss as 1/8" thick. If graphic symbols and interconnecting flowline are all fabricated from the same thickness stock, tolerances in material thickness would result in mismatch and therefore necessitate troublesome fitting at flowline and symbol junctions. (Fig. 4).

Forming of symbols from heavier sheet materials requires special techniques as well as equipment to insure sharp clean edges. All cut edges must be processed to remove tool marks and give a satin-type finish.

Mounting procedure is to place equipment and instrumentation designation symbols first, with interconnecting flowline added to suit. Where thermoplastic materials are specified for flowline, bends and corners can be formed by application of the proper combination of heat, pressure and a bending mandrel. Separate elbow sections and mitered joints also are employed (Fig. 5).

Metal Components

With mechanical (nut and bolt) mounting, graphic components usually are fabricated from metals. As metal plate thickness tolerances can be controlled closely, mismatch between abutting graphic components need not be considered. For this reason it is both practical and economical to fabricate a graphic system wherein all symbols and interconnecting flowline, or electrical buss, are specified ⅛" in thickness. This raised graphic, with all components of ⅛" thickness, forms a three-dimensional display for ease of reading and eye-catching appearance. It can be mechanically bolted to the panel surface, and the ⅛" metal stock can be formed at comparative low cost.

While anodize dye-color type finish occasionally is called for, this is costly. Any variation in grain structure or alloy of the raw materials from which symbols are fabricated will result in parts of different hue, even though processed together under identical conditions. Color durability and fade resistance is poor. Additions and modifications to existing installations are a special problem in that old and new parts must be color matched. When anodize finish is specified, and modifications are anticipated, the least costly procedure is to specify that a certain percentage of spare parts be furnished with the original order. These spare parts should be stored, if possible, under conditions similar to those at the panelboard installation.

For less costly, most easily controlled, more durable and fade-resistant finishes, any of the many high-quality paints, including Vinyls and Epoxies, can be specified. Complete finishing cycle should include degreasing, chemical pretreatment, and pigmented prime.

Engraved component identification legends, and internal details for graphic symbols should be inlaid with a contrasting color paint. This is preferred to leaving the metal exposed.

When human engineering is considered a design factor, it is desirable to have key features of the graphic display—process equipment and instrumentation designation symbols—stand out beyond items of secondary importance. This can be done by fabricating the former with 3/16" or ¼"-thick material, and the latter with ⅛"-thick material. The resultant three-dimensional system insures easy recognition of components even when the operator is standing to one side of the control panel. Combining such a system with a suitable color code scheme produces a distinctive graphic display.

Selecting the System

Factors to be considered are:

Anticipated frequency of modification:

Pressure-sensitive adhesive-backed graphic components lend themselves best to frequent modifications and additions.

Human engineering:

Three-dimensional graphic components, adhesive-backed plastic materials, and mechanically-mounted metal materials most fully meet graphic-display objectives by providing an easily-read picture of the process or cycle.

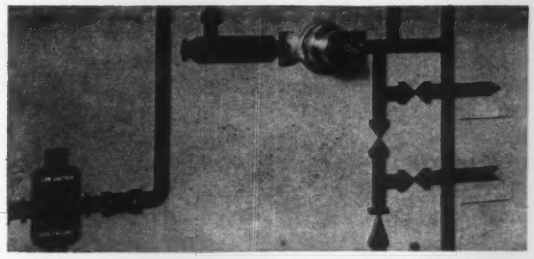


FIG. 6. AS ALL graphic components are formed from a single sheet of stock, layout, fitting and mounting of individual components is eliminated. The resulting jointless display is achieved at moderate cost.

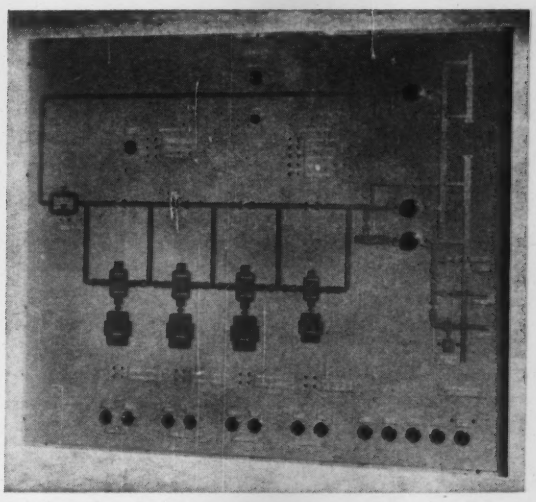


FIG. 7. NEWLY-DEVELOPED fabrication machinery can form a complete graphic picture from a single sheet of metal or plastic stock. Thus, all symbols and flowline are pre-joined. Forming costs are lower, as compared to individual components, and the entire picture can be assembled onto the panelboard as one piece in a few minutes.

Ambient conditions of the installation site:

Only mechanical mounting of graphic components should be specified where high temperatures, solvent and oil-mist atmospheres are to be encountered.

Cost:

Design life span should be considered. Lowest initial expenditure does not always prove to be most economical where life expectancy is five years or more.

Special Construction

A *condensed graphic display* makes possible a complete system within a small area. Here, only process indication lights, and, occasionally, push-buttons are located within the graphic picture. The complete picture is located either directly above, or, in the midst of rows of instrumentation. Color coding, colored nameplates or colored instrument bezels relate graphic components and sections to corresponding instrumentation.

A device now makes possible fabrication of complete condensed graphic displays from one single piece of sheet stock. Graphic symbols and flowline are prejoined. As only one item need now be mounted onto the panel surface, panel assembly time can be decreased by 95%. Graphic picture layout, location of individual symbols, cutting, fitting, and placing of flowline are all eliminated (Figs. 6 and 7). Pressure-sensitive single-plane plastic sheet stock, and mechanically-mounted metal sheet stock are the most common materials of fabrication.

Imprinted Plastic

A distinctive display can be prepared from colorless, transparent, plastic sheet materials, 3/16″ to ¼″ thick. The complete graphic picture, along with all identification legends, is imprinted into the rear face of the clear plastic sheet. The imprinted lines are filled with various pigments which complement the background panel finish. The deeply imprinted lines of the graphic picture appear to stand off the panel surface thereby giving an illusion of depth. This system lends itself well to both the full and condensed graphic layout.

Fabrication costs with this technique are higher. However, the completed display is quickly mounted as one piece. Thus, total costs, including fabrication and installation, become competitive with a system made of individual components.

Selective Illumination

A single component can be illuminated in a series of colors. A pump or motor symbol, for instance, can be made to glow green for normal operation, red for failure or danger, orange for standby.

Low-voltage operation is desired for long life. Care must be taken to avoid light bleeding or mixing where two graphic components are joined together. Also, serviceability must be kept in mind.

Standardization

To date, no industry-wide, accepted standards exist. To help reduce the great variety of shapes and forms employed in preparing graphic display layouts, the more frequently-recurring components, such as valves, pumps, tanks, towers, and many others, are now made available—both in plastic and metal materials—as shelf-stock items. Charts have been prepared listing these components with identifying part numbers, and simplified systems have been developed to locate cutouts and specify color requirements.

Such measures offer a degree of standardization. The concept needs to be carried to fulfillment by accepted technical societies.

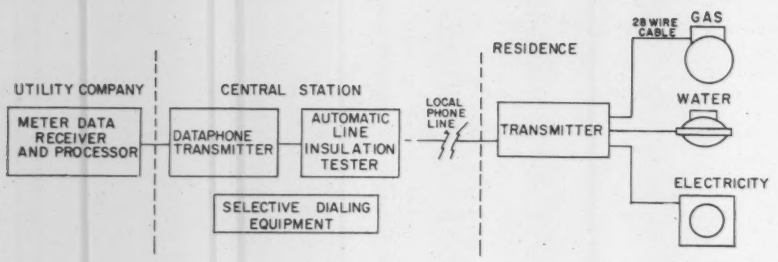


FIG. 1. BLOCK diagram of system.

Remote Utility Meter Reading

Some economic advantages and technical details of a commercially available Automatic Remote Meter Reading System for domestic and industrial utilities—gas, electric and water.

A. BROTHMAN
E. W. LEWISON
Electronics Division
Industrial Process Engineers Inc.

GAS, ELECTRIC AND WATER meters present an opportunity for apparatus sales in large quantities—if an inexpensive data-transmitter could be developed embodying the all-important features of operational reliability, transmission security and accuracy. Automatic reading and billing would have many advantages, including (1) income would be received earlier, (2) clerical staff used to transcribe the written reports of meter readers would be eliminated, (3) all costs associated with meter readers would be eliminated, including insurance and cost of automotive equipment, (4) automatic equipment, once installed and paid for, does not go up in price, as does human labor, (5) inconvenience to householder and power company when indoor meters are read would be eliminated, (6) the electronic system is much less susceptible to error than are humans, (7) loading could be studied hourly or momentarily, as required, (8) off-peak power could be sold, allowing the power company to render better service to interruptible consumers, (9) better use of production, storage and transmission facilities could be made because the system opens the way for economical computer control of dispatching on even branch-line distribution networks.

At each metering point, the I.P.E. Metering System uses the existing utility meter to drive a four-character position encoder. A transmitter applies the coded data to a telephone link. At each utility company the system uses a data receiver and processor to prepare the incoming meter information for automatic filing and dispatching. The telephone link practices vary according to the frequency with which a given meter is read.

Coded Readout

Home utility meters (gas, water and electricity) usually consist of a basic measuring device which powers a visual readout register. The register generally consists of an input gear train to a units countershaft, and successive 10-to-1 gear reduction stages driving decade counter wheels.

In superimposing a coded readout capability on the basic meter movement, one of two methods is employed—(1) the existing register is removed and replaced with a coded and visual readout register or (2) means are arranged for the pickup and transfer of the units counter shaft motion to an external coded readout register.

The coded readout register is an exact duplicate of the existing register except that it contains a brush-and-commutator auxiliary on each indicator shaft. This auxiliary consists of a 7-track cylindrical commutator and seven "cat's whisker" brushes held in a common stationary holder. The commutator has 0-1-2-3-6 code so that each of the numerically significant positions of the shaft can be read without ambiguity. A meter reading is gathered when the brush assemblies are "interrogated" in turn. That is, the brush assemblies are interrogated in order of their declining importance—the "units" wheel in-

terrogated last. A complete reading of one meter takes 1.5 seconds.

Some industrial utility meters employ integral registers, some provide shaft extensions for external counters, and some provide intermittent contact action for pulse counters. Meters which have registers included are treated in the same manner as home meters. Meters which provide shaft extensions or contact actions are equipped with I.P.E. coded readout counters.

Transmitters

The transmitter, at each metering point, responds to a "request" with a *meter reading message*. The transmitter can (1) complete a "message loop" in response to a "selective ring," (2) identify itself by a coded address, (3) serialize the register's coded readout, and (4) terminate the message loop after a complete message has been keyed out.

It is possible for a single transmitter to be shared by two or more meters; apartment-house transmitters can read from 25 to 200 meters. Shared-use transmitters of all types pay out all of their readings sequentially, in answer to a single request. Each readout is identified by its own meter number.

Telephone Systems

The frequency with which meters are read is dictated by load and accounting requirements. Normally, private-dwelling and apartment-house meters require no more than one reading each month. Industrial meters may require daily reading.

In the case of meters which are read frequently, the call code of the transmitter is dialed out and is processed through the telephone company's selective dialing network to the transmitter. On the resultant selective "ring" to the transmitter, the transmitter responds with its coded messages, and releases the line after its last reading message has been keyed out.

The dialing of the transmitter call codes is carried out by automatic dialing equipment at the utility company's billing or dispatching office. The sequence and the codes themselves are read from punched paper tapes to the telephone link by the automatic dialing equipment. The dialing equipment is "locked" with the Meter Data Receiver and Processor so that each new call-request is made after all reading data resulting from the last call has been reecived and taped. In returning its reading messages, a transmitter which has responded to a selective "ring" through the selective dialing equipment will use a Data Tone Set.

Independent phone lines to transmitters are not economic for reading individual domestic meters or small clusters of meters. In these applications the I.P.E. Reader System is used "piggyback" on the regular telephone service to the home.

The piggyback technique places minimum taxation on the telephone system. Meter-reading requests are made a part of a normal routine maintenance check now made of subscribers' lines by each Central Office, and the reading messages would be received during the test-cycle at each subscriber's line. In present practice, the tests are imposed by a standard Central Office test set known as ALIT (Automatic Line Insulation Tester). This performs a resistance and high-voltage-breakdown test schedule at each subscriber line on a sequential scan basis during the off-peak loading periods of the message network. Of the two tests at each line, the high-voltage-breakdown test acts as an inaudible "selective ring" to each transmitter. The transmitter then responds using a metallic keying action similar in form to the action of a telephone dial head. When these pulses are received at the Central Office, the "common arm" of the ALIT applies them to a Data Tone Set for retransmission to the Utility Company's Billing Center. Modifications of the ALIT to meet these requirements are easily made.

The responding message is a reading of each of the domestic utility meters in sequence. The Central Office directs the requested reading to the proper utility. Thus only the gas company receives the gas data, etc.

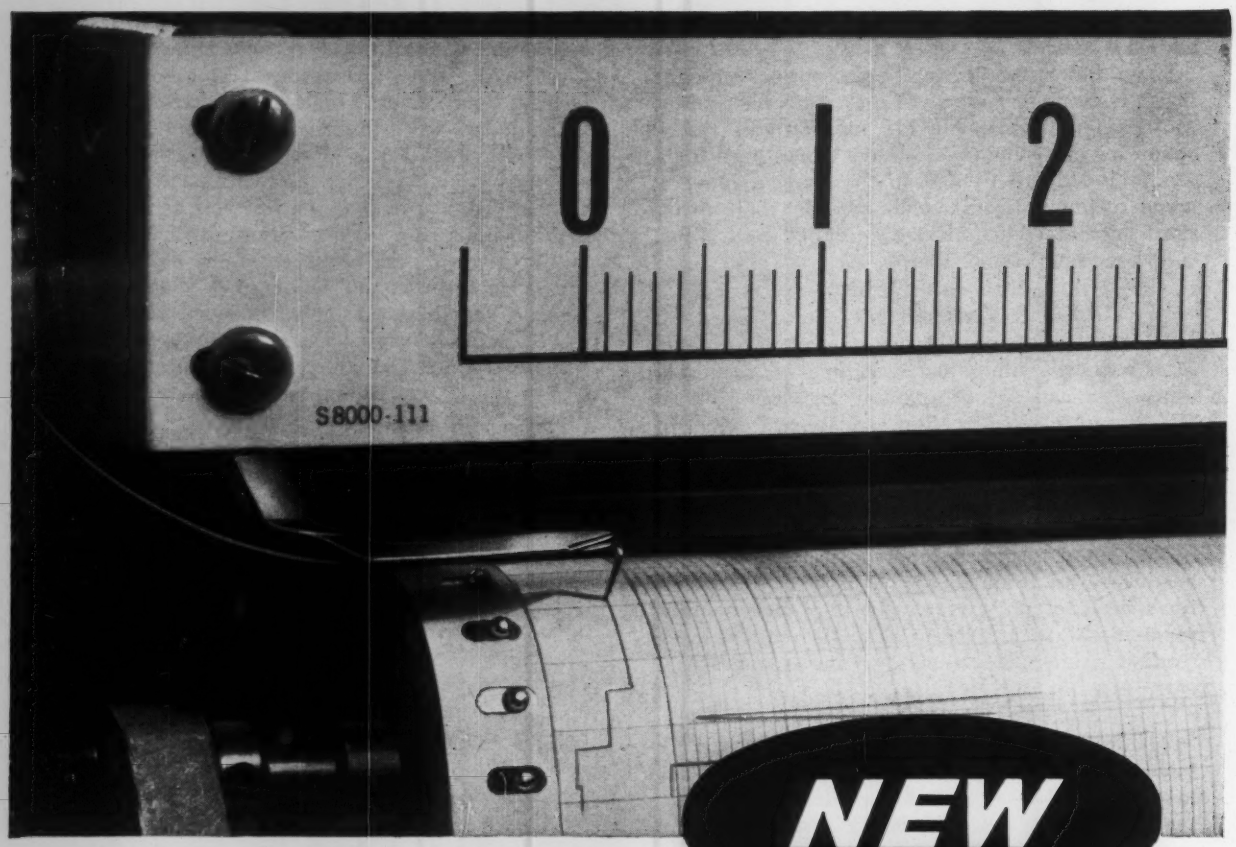
The Central Office area collection scheme offers advantages to both the Telephone Company and the Utility Companies in that it provides the former with an off-peak remunerative load at a low capital investment, and also provides an economic foundation for the automatic reading of domestic meters.

Meter Data Receiver and Processor

Regardless of whether the Reading Message requests are made in conventional fashion (through the selective dialing equipment of the Telephone Company "message network") or through the ALIT, the incoming reading messages are received, checked, and recorded at the Utility Company's Data Receiving Center. The receiving, checking and recording functions are performed by the *Meter Data Receiver and Processor.*

The receiver capability of the Meter Data Receiver and Processor includes a deciphering capability for each Transmitter Message, an ability to program accessory Automatic Dialing Equipment, and an ability to receive and deliver interlocking signalling to the Central Office ALIT during the reading of private home meters. The checking capability of the Receiver and Processor includes error-monitoring against transmission hazards, the checking of each meter number or address for completeness, and the elimination of ambiguities from reading characters or digits "hanging on the edge" of change. Over and above these primary checking functions, the Receiver and Processor notes all "fail-to-answer" requests, all incomplete answers, and all "busies" encountered during a sweep.

Finally, the Receiver and Processor produces two output records from the received Messages: (1) a Checked Data Tape which can be submitted as such to a billing Computer and Data Processor, or which can be typed for a dispatcher by an automatic typewriter; and (2) a Fault Tape and typewriter Fault Log contained errored messages, "fail-to-answer" calls, "busies" and complete answers, all properly identified.

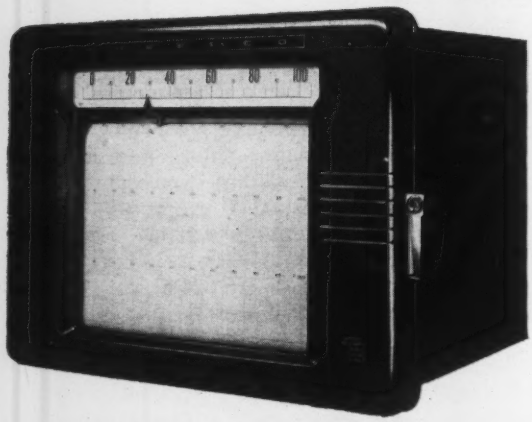


. . . through research by Barber-Colman

Equivalent 50-inch scale 5 *automatic* zero shifts

Automatic Extended-Range Recorder

Industry is offered a precise instrument to measure unknown or widely varying potentials in process control — reliably, accurately, automatically. Up to five steps of Zero suppression is equivalent to a 50-inch scale. Any basic span from 2 to 250 mv can be chosen; Zero suppression does not change span. For more details on this exciting instrument, contact any Barber-Colman, Wheelco Office — see the Yellow Pages.



BARBER-COLMAN COMPANY
Wheelco Industrial Instruments Division

Dept. T, 1515 Rock Street, Rockford, Illinois, U.S.A.
BARBER-COLMAN of CANADA, Ltd., Dept. T. Toronto & Montreal • Export Agent: Ad. Auriema, Inc., N.Y.

CIRCLE 63 ON READER-SERVICE CARD

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

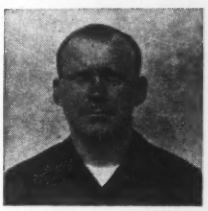
President: *J. Marvin Lange*
Vice-President: *Ray D. Smoot*
Auditor: *Herbert L. Clark*
Program Chairman: *Robert D. Foster*
Secretary-Treasurer: *Glen C. Wilson,*
10219 *Orange Ave., South Gate, California.*

Controlling The Big Squirt

A discussion of the controls, instrumentation, and related operational difficulties of the world's largest underground water injection system.

H. J. VAN HATTEN
Natural Resources Division
Union Pacific Railroad Company

HUGH J. VAN HATTEN graduated from University of Nebraska with BSME in 1954. He spent three years as Engineer and Amphibious Bulk Fuel Officer in the U. S. Marine Corps; Completed U. S. Navy Petroleum School, Pearl Harbor. He joined the Union Pacific Railroad in 1957 as a mechanical engineer in the Natural Resources Division. He is 30 years old, married.



Presented at Southern California Meter Association, Tenth Annual Instrument Application and Maintenance Short Course, Los Angeles Harbor College, Wilmington, California, March 28 and 29, 1961. The statements and opinions expressed herein are those of the author and should not be construed as an official action of the Southern California Meter Association or Union Pacific Railroad Company.

There will be no regular meeting on Sept. 21, 1961 at the Rio Hondo Country Club, Downey, Calif. Instead, the SCMA is cooperating with the ISA by providing two technical sessions at the 16th Annual ISA Conference and Exhibit, Los Angeles, Sept. 11-15, 1961.

THE BLOCK II-III WATERFLOOD in the Wilmington Field was started in October, 1959. The waterflood consists of two systems, Mainland and Terminal Island, which have a combined capacity of 448,000 barrels per day; thus the construction program was tabbed by local newspapers as "Operation Big Squirt."

The purpose of the systems is (1) to supply water to subsurface strata as an aid in abetting subsidence and (2) to provide a method of secondary oil recovery. The systems provide water from source wells, raise it to the desired pressure at the injection plants, and distribute the water through three systems, each at different pressures. As both Island and Mainland systems are similar, discussion will be confined to the Mainland system, the world's largest injection system.

The system can be separated into three subdivisions:

1. Water source wells and supply lines.
2. Water injection plant.
3. Distribution system.

Instrumentation and controls for each subdivision are varied and fitted to the system's requirements.

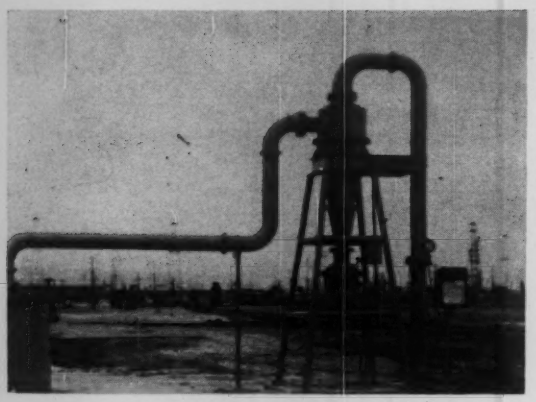


FIG. 1. Typical source well with desander.

FIG. 2. Pressure reducing and check valve.

Source Wells

There are 10 water source wells in the Mainland system. Water wells were drilled in preference to taking water directly from the ocean. Although the water from the source wells contains approximately as much salt as sea water, the well water contains less oxygen, and has the added benefit of being filtered by the subsoil.

Water is lifted from the substrata by means of 3-stage, submersible stainless steel pumps with 75-hp submersible motors. Originally, the pumps were 4-stage units. Due to the high fluid level, one stage was dropped to give more efficient operation. The source wells are generally about 200′ deep with pumps set at a depth of about 100′.

After leaving the well, the oxygen-free salt water passes through a rubber-lined desander, which removes suspended solids. It should be pointed out that the source-water piping is coated with epon fumaric resin to protect against corrosion. From the desanders the water passes through a *flowtube* which measures the well's gross output. The flowline then branches (Fig. 1).

One branch is controlled by a *combination pressure-reducing and check valve* which maintains pressure to the injection plants (Fig. 2). The set pressure is adjustable. The second branch, to the ditch, is controlled by a *pressure-relief valve*, also with adjustable set pressure. By this arrangement, a predetermined back pressure may be held on the source-well pump and motor to obtain maximum efficiency. Additionally, a lower source line pressure can be maintained to produce maximum injection pump efficiency.

Let us return to the desanders for a moment. The recorder and connected *flow tube* are located to one side. Both *well volume* and *source line pressure* are recorded (Fig. 3).

Below the desander, a grit pot is suspended. Attached to the grit pot is a *radioactive level detector* used to detect the sand level. The use of radioactive materials as a measuring or detecting device is relatively new to industry. It has been found from a statute control standpoint, that the use of natural radioactive material is much more desirable than the use of produced or by-product radioactive material because (1) the natural material is not rigidly controlled, (2) natural radioactive material need not be licensed and (3) fewer records need be maintained. The radioactive source is attached on one side of the grit pot. The counter tube is placed on the opposite side. Initially, the radioactivity emission level was determined with and without sand in the grit pot; the trip point, which shuts the source well down, was set accordingly. Equivalent thicknesses of lead, to simulate the sand, are now used to check the calibration. The level detector prevents quantities of sand from being produced into the system.

At each source well the *static fluid level over the pump* can be determined by use of a nitrogen gas cylinder with a polyethylene tube running to the pump suction. A direct reading gage is attached to the nitrogen cylinder. The branches of the source line join at the injection plants. As noted previously, all source lines are coated from the source well pump to the injection pumps to protect against corrosion by the salt water.

Pump Controls

At Mainland, there are 8 injection pump units. The drip-proof motors range from 450 to 900 hp and are 2-pole, 2300-volt, with weather protected enclosures. The Mainland plant has a nominal capacity of 290,000 barrels per day. The Island plant has 6 injection pump units with a nominal plant capacity of 158,000 barrels per day (Fig. 4).

There are various controls on the pump equipment, permitting the plants to be unattended. The motors have several safety devices. They include phase balance relays, thermal relays, over-current fuses, arc dissipators, and motor-bearing-temperature mercury switches.

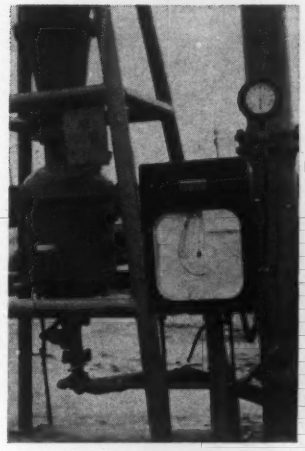


FIG. 3. Grit pot with radioactive source.

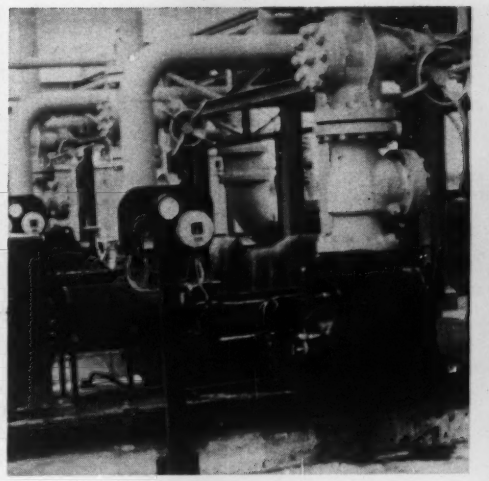


FIG. 4. Typical injection pump and motor.

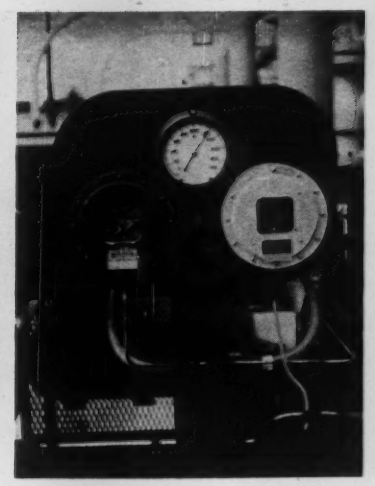


FIG. 5. Suction pressure and discharge water temperature controls.

The centrifugal pumps range in capacity from 780 to 1120 GPM (at design point) and are constructed of stainless steel. Packing was originally specified for start-up purposes, but is being replaced by mechanical seals as conditions warrant. Centrifugal pumps were chosen because of initial cost, lower maintenance cost and high efficiency at design point. All safety devices are tied into the motor circuit which, if any one safety device trips, shuts down the pump unit and actuates audio and visual alarms.

The *pump bearings* are protected by *copper-constantan thermocouples* wired to galvanometers which are preset to trip at the specified maximum operating temperature. It was found that vibration caused almost total failure with the indicating galvanometers. It was necessary to (1) mount the instruments in 50-durometer-hardness rubber, (2) remove rigid connections between the panelboard and the structural steel, and (3) provide flexible electrical conduit into the board on which the instruments are mounted.

A *pressure mercury switch* is used on the pump suction lines to protect against a pump running dry in event of a source water failure. It was necessary to use higher range mercury switches than were initially installed because the surge in the water source line created by a total plant shutdown caused the mercury switches to reset, and in some cases caused the bourdon tube to be permanently distorted or ruptured. The orifice generally used in this type of device (to protect against line surges) could not be utilized because it had a tendency to become plugged and render the bourdon tube inoperative and the switch useless. In addition to using higher range mercury switches, a surge stack was added to aid in absorbing the shock.

On the pump discharge is located a *discharge-water temperature mercury switch,* providing a double safety in event of source water failure, and also providing a safety in event a pump unit is discharging to a blocked line. (Centrifugal pumps can run against a closed valve only for a short period of time without being damaged.) After installation it was found that the mercury switch was set to trip at too high a temperature, and the gas-filled temperature-sensing bulb was placed too far from the pump to provide adequate protection. This situation has been corrected by (1) moving the temperature-sensing bulb closer to the pump discharge and (2) lowering the trip point. Fig. 5 shows the controls for suction pressure and discharge water temperature.

Instrument Air Supplies

The injection-water pressure-control-system instruments are pneumatically controlled from air supplied by a 18-cfm, single-stage, electrically-powered compressor. Immediately downstream of the compressor is an auxiliary air supply connection, felt filter, air-pressure regulator, and relief valve. The instrument air supplies the pneumatic requirements for the differential-pressure cells, the pressure proportional controllers mounted in the meter cases on the panel, the valve positioners on the pressure control valves and, in turn, to the pressure-control actuators.

Valve Problems

There are three pressure-control *valves,* one for each pressure system. The three pressure systems are nominally rated at 800 psi, 1000 psi, and 1200 psi. Six months after plant start-up a situation developed whereby the pressure could no longer be controlled in the 1200 psi terminal system. The top works were pulled for inspection. It was found that the carboloy tip had broken (Fig. 6). The stellite jacketed stainless-steel plug, the stainless-steel plug guide, and forged steel top flange were severely eroded. The pressure drop across this par-

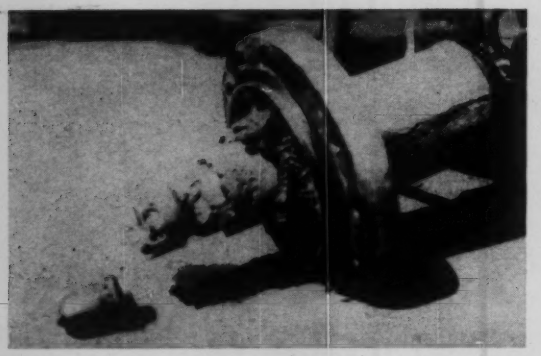


FIG. 6. Eroded pressure-control valve.

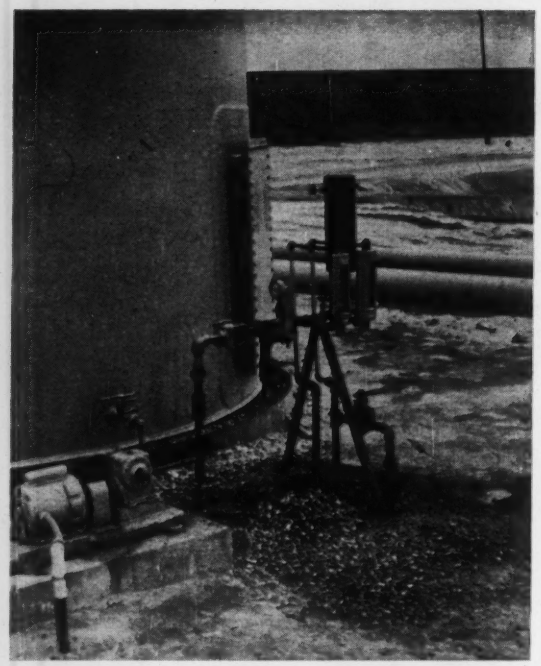


FIG. 7. Bacteria-inhibitor-pump rotameter tubes.

ticular valve is about 1200 psi. The flow pattern was such that the flow entered one side of the valve, up through the orifice against the plug and top works, and out the other side. The immediate thought was to reverse the flow, simply by turning all the valves end for end. Within a month, the bottom of the valve bodies began to erode out. This presented a problem—which could be corrected more easily, top works erosion or valve body erosion? It was felt that, with proper modification, the valve body could withstand the reversed flow conditions.

Three solutions to the problem were considered: (1) To convert the valve to an angle valve with the stream leaving the bottom of the valve body; (2) to mount the regulation assembly over a large tank and discharge into water which would act as a cushion; and (3) to have the water of the regulating section discharge into a stream with an opposing flow, thereby cancelling out the velocities.

As each regulator developed an eroded bottom due to the reverse flow, it was decided that a pot or well would be welded to the body to match the eroded valve bottom area, thus enabling water to act as a cushion. One valve for experimental purposes was converted to an angle valve with discharge out the bottom. Since this conversion twelve months ago, no pressure-control valves have caused difficulty due to body erosion.

Corrosion and Bacteria Chemical Addition

A portion of the air supplied by the compressor is used to operate the *Annin Domotor* connected to a *variable-speed transmission* on the corrosion inhibitor chemical pumps. The Domotor also receives a pneumatic signal indicating water input to the plant. This allows constant parts-per-million of chemical to water to be supplied, should the gross water throughput vary. The parts-per-million of chemical to water can be changed by adjusting the pump stroke. Although the system is essentially oxygen free, it was felt that a corrosion inhibitor was necessary should air enter the salt water (because of repairs, system modification, or inspections) and to control corrosion in uncoated lines and the injection well tubing.

In addition to the corrosion-inhibitor pump at the plant, a *bacterior-inhibitor pump* is installed at the end of each water source system. Rather than install additional compressors for use with a pneumatically operated variable drive, a constant-speed drive is used with a test port available to determine the proper pump output. Positive-displacement meters have been installed on each chemical pump discharge for more accurate control. Once the rate is determined, the bacteria inhibitor can be apportioned to each leg of the source system by use of *Flowrator tubes* (Fig. 7).

Surface Facilities

The surface facilities of a typical injection well consist of a pulling mat, wellhead equipment, orifice meter run with a bellows-type recorder, and flow bean for regulation purposes.

At the extremities of each injection system is located a corrosion test station. A test station generally consists of two honed, measured, and weighed test spools, a corrosion probe, and coupon holder. These tools provide a method of determining the corrosion rate and to make adjustment in the chemical treatment program.

Acknowledgement

The author expresses appreciation to the management of the Natural Resources Division of Union Pacific Railroad for permission to publish this paper.

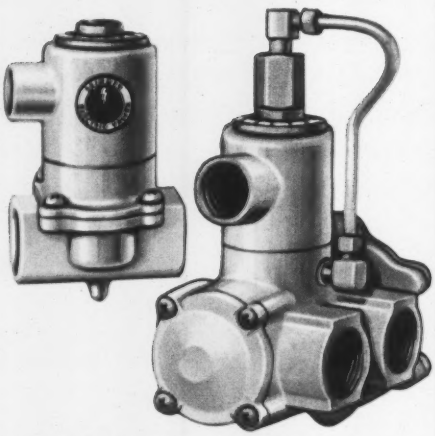
CIRCLE 87 ON READER-SERVICE CARD——→

SKINNER EXPLOSION-PROOF SOLENOID VALVES

Skinner has a complete range of Explosion-Proof Solenoid Valves

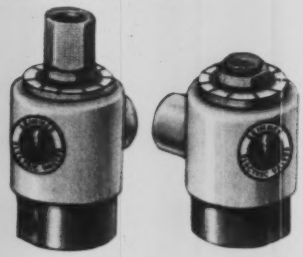
If you have a control problem involving valves operating in hazardous locations—Class I Group D (gasoline vapors, etc.), Class II Group F (coal and coke dust) and Group G (grain dust)—you can select from Skinner's complete line of two- and three-way explosion-proof standard and high pressure solenoid valves.

- **U.L. approved**
- **A wide range of pressure ratings and orifice sizes**
- **Bodies and coil housings machined to close tolerances—clearance is 0.0005**
- **Stainless steel or naval brass bodies**
- **Stainless steel internal parts**
- **Stainless steel and brass internal parts**



STAINLESS STEEL TWO- AND THREE-WAY SOLENOID VALVES—X5 SERIES

The highest quality and most versatile valves manufactured. So flexible that basic valve can be modified to provide porting, mounting, or flow-control, to meet most applications.

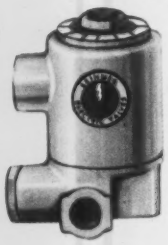


Two-way solenoid valves are available normally closed, normally open and dual purpose. Orifice sizes from $\frac{1}{32}$" to $\frac{3}{8}$", maximum operating pressure differential 3000 PSI depending on orifice size—NPT pipe size $\frac{1}{8}$", $\frac{1}{4}$" and $\frac{3}{8}$".

Three-way available normally closed, normally open, directional control and multi-purpose. Orifice sizes from $\frac{3}{64}$" to $\frac{1}{4}$", maximum operating pressure differential 200 PSI depending on orifice size.

TWO-WAY PISTON TYPE SOLENOID VALVES—XR SERIES

These valves, with forged naval brass body and stainless steel piston, handle high flow and high pressure requirements of industrial and commercial applications with most common media.



XR series valves are available with $\frac{1}{4}$" orifice and $\frac{1}{4}$" NPTF in normally closed or normally open construction. Operating pressure differential 5 to 1250 PSI for AC operation and 5 to 1000 PSI for DC operation.

TWO- AND THREE-WAY HIGH FLOW SOLENOID VALVES—XL SERIES

These diaphragm type solenoid valves meet the high flow requirements of a great many commercial and industrial applications. The unique Skinner diaphragm construction makes possible the exceptionally long service life of this series valves.

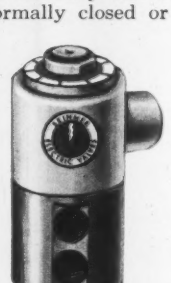
Two-way XL series valves are available normally closed and normally open. Orifice sizes are $\frac{1}{2}$", $\frac{3}{4}$" and 1" with corresponding NPTF pipe connections. The $\frac{1}{2}$" orifice model is also available with $\frac{3}{8}$" NPTF. Operating pressure differential is 5 to 150 PSI.

Three-way XL series valves are available normally closed, normally open and directional control. Orifice sizes are $\frac{3}{8}$", $\frac{1}{2}$" and $\frac{3}{4}$" with corresponding NPTF pipe connections. Operating pressure differential is 5 to 150 PSI for the $\frac{1}{2}$" and $\frac{3}{4}$" size and 10 to 150 PSI for the $\frac{3}{8}$" size.

TWO- AND THREE-WAY HIGH PRESSURE HYDRAULIC SOLENOID VALVES—X10 SERIES

These stainless steel, direct acting, slide-type valves are precision engineered to control hydraulic systems at pressures up to 2000 PSI.

These high pressure hydraulic valves have a $\frac{3}{32}$" inlet and cylinder orifices with $\frac{1}{8}$" NPT. They can be used as two-way normally closed or two-way



normally open valves by plugging the appropriate port, and three-way normally closed, or three-way normally open, or dual purpose valves.

• • •

For complete information, contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed nationally.

SKINNER ELECTRIC VALVES ®

THE CREST OF QUALITY

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION
SKINNER PRECISION INDUSTRIES, INC. • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.

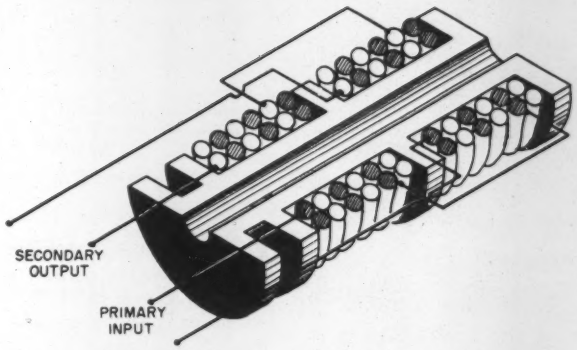


FIG. 1. PRIMARY and secondary windings are wound together for better linearity.

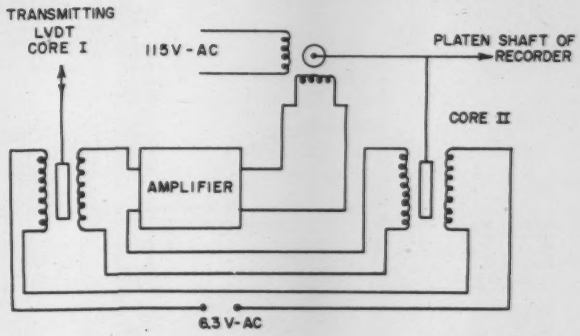


FIG. 2. EXTERNAL wiring of null-balance LVDT system.

The Universal Precision Dilatometer

Dilatometry, the quantitative study of thermal expansion, has been under investigation for many years by many metallurgists. This dilatometer records thermal expansion automatically.

G. L. CUTLER
Knolls Atomic Power Laboratory
Schenectady, N. Y.

WHILE many older dilatometers give reasonably accurate results, nearly all have one common drawback—fairly constant operator attendance is necessary to take data.

The automatic, self-recording apparatus presented here provides reasonably accurate determination of thermal coefficients of expansions up to 1050°C (1922°F) of any workable solid material in an inert atmosphere, or in a vacuum to 3×10^{-6} Hg. This has been developed by, and is in use at, the Knolls Atomic Power Laboratory.*

The LVDT

The displacement due to thermal expansion is detected by a linear variable differential transformer (LVDT). In order to make the electrical response linear, many designs were tried for the LVDT. The most linear response is accomplished by winding the primary and secondary together (Fig. 1).

A two-phase motor drives the core longitudinally through the LVDT. One motor winding is connected to the 115 v a-c line, and the other winding is energized by the output of a three-stage amplifier, which is fed the signal from the LVDT secondary. By connecting a second LVDT (known as a transmitter) in series with the first LVDT (Fig. 2), any movement of the first core causes an unbalance of the phase relationship of the motor windings. This causes the motor to rotate, moving the core in the receiving (second) LVDT until the two motor windings again see signals 180° out of phase. The system has now reached a null-balance point and motor rotation ceases. The second core moves whenever the transmitting core moves. The transmitting core is moved by the expansion or contraction of the specimen. As the motor is phase sensitive, it

*Operated by the General Electric Company for the United States Atomic Energy Commission.

←—CIRCLE 87 ON READER-SERVICE CARD

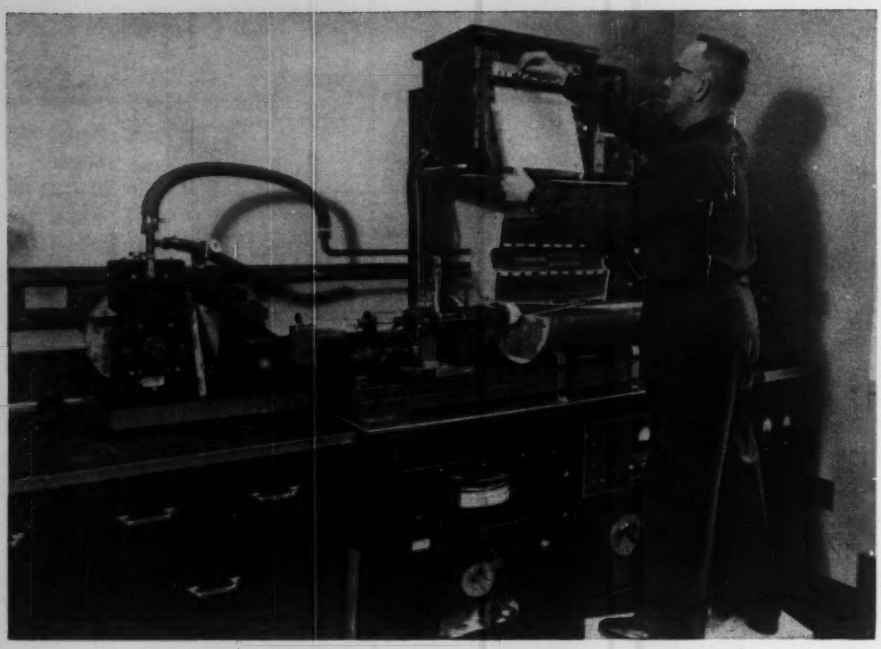


FIG. 3. DILATOMETER with furnace opened. Vacuum pump is at left; recorder is above apparatus.

distinguishes between direction of phase displacement, and rotates accordingly.

The Dilatometer

The diversity of materials to be tested at KAPL required a high-vacuum dilatometer. The dilatometer comprises (1) a quartz furnace tube with a "grade" to the pyrex high vacuum system, (2) a furnace and associated electrical system, and (3) the specimen holder with its accompanying electronic equipment (Fig. 3).

In designing a vacuum dilatometer it is necessary to remove as much non-quartz materials as feasible from the vacuum system. At the same time, experience had shown that the thermocouple wires could be run in regular ceramic tubing in the evacuated section, but the wires themselves should be removed from the magnetic flux field of the LVDT to remove a possible source of non-linearity. It also was necessary to have the entire measuring system removable from the furnace in order to facilitate repairs, replacement of thermocouples, and insertion and removal of specimens.

The dilatometer head is shown in Fig. 5. Quartz is used throughout the main measuring system to eliminate as much of the effects of unequal thermal coefficients of expansion as possible. A grade to FN glass and Fernico seals brings the thermocouples out of the vacuum system.

The specimen holder (Fig. 4) was kept in proper alignment during assembly by graphite jigs; this made the rod free-sliding. This was made necessary because the strength of the phosphor-bronze return spring must be limited to prevent deformation of specimens—some materials become plastic at temperatures within the range of the equipment. Fig. 4 shows the specimen in place (far right) in the fixture which is inserted into the vacuum system.

The Furnace

Split-furnace design permits final inspection of the specimen and holder when assembled in the middle of the quartz furnace tube. The furnace (Fig. 6) is capable of continuous operation at 1010°C (1850°F) and has a compensating winding to give a constant-temperature zone approximately 4" long at about the center of the furnace.

Temperature Measuring and Controlling

Two independent thermocouples are used for temperature measurement and control. One thermocouple is in contact with the quartz holder frame adjacent to the specimen (see Fig. 5), and is connected to the program controller. The other is in direct contact with the specimen, and is connected to the recorder.

A proportioning-type program controller (0° to 1200°C range) used with a chromel-alumel thermocouple is capable of holding temperatures constant within approximately ±1°C. Program discs can be cut to provide any desired temperature pattern. Similarly, the input power to the furnace also is program controlled for smooth results.

The Vacuum System

The vacuum system is composed of a mechanical forepump, oil diffusion pump, two cold traps, two ion tubes, and a Pirani gauge tube set. This pumps the furnace tube down to a vacuum of about 3 x

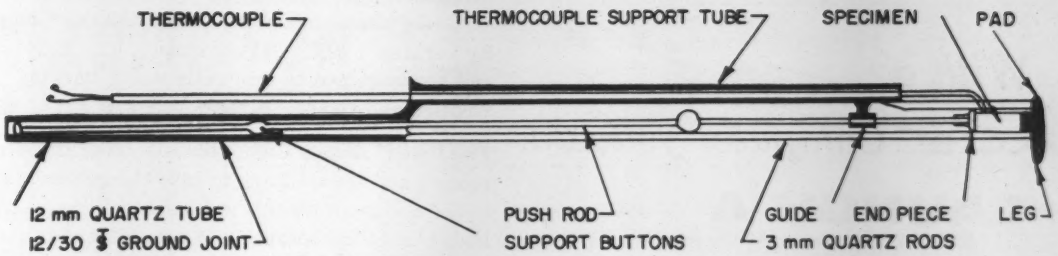


FIG. 4. DILATOMETER specimen holder and push rod.

10^{-6} mm Hg pressure, which is adequate for protection of the high-oxygen-gathering materials.

The Recorder

The recorder is a single-point strip-chart type with a 0°C-to-1650°C range, using a platinum/platinum-10% rhodium thermocouple.

This recorder was modified for the purpose of recording temperature against dimensional change. This modification involved removing the chart drive and installing the measuring equipment—the amplifier and the null-balance hardware. The two-phase null-balance motor is coupled directly to the chart roll. The direction of rotation is such that the chart moves down for expansion and up for contraction of the specimen. The drive ratios provide 1" of chart travel per 0.001" expansion of the test piece. The conventional temperature-recording mechanism moves the pen across the chart simultaneously, thus giving a record of temperature versus dimensional change.

For determining dimensional changes at constant temperature, the furnace is first brought to a preselected temperature. Then the recording thermocouple is switched to a device that starts at 0 millivolts and increases linearly to 17.26 mv (which is the equivalent of 1650°C) driving the temperature-recording pen across the chart in 24 hours. This unit can be reset to zero as many times as desired depending on the length of the constant-temperature run. This arbitrary transverse trace permits recording any dimensional changes occurring at constant specimen temperature.

The Specimen

This apparatus is designed primarily for round specimens ½" dia. by 1" long; however, by using various inserts in the specimen holder and by changing the push rod length, cross-section geometries of various designs can be used, thus allowing the investigation of the effects of shape and size on the thermal expansion characteristics of a material.

Summary

Runs on stainless steels show close correlation with published figures (Fig. 7); phase changes show up readily. Operator attendance is not required, which means tests can be conducted on a round-the-clock basis.

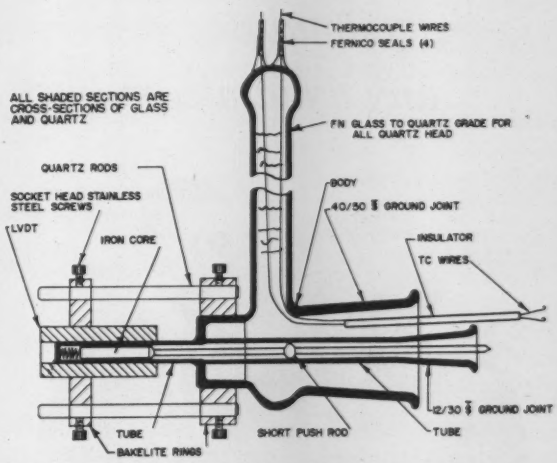


FIG. 5. CROSS-SECTION of dilatometer head.

FIG. 6. SPECIMEN and holder are shown above furnace.

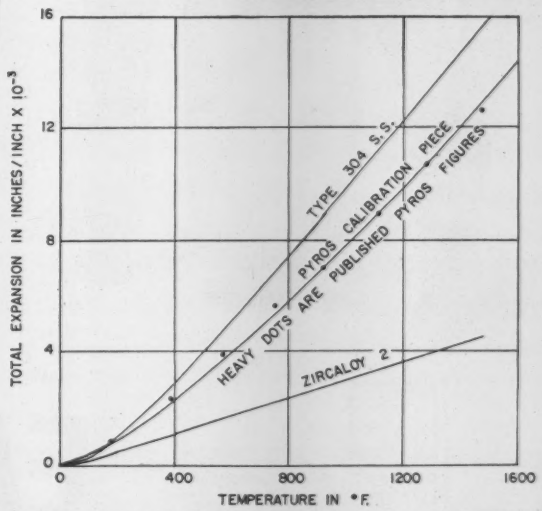


FIG. 7. TYPICAL thermal expansion curves as determined by dilatometer.

With a

PACE® *Computer you can*

LAUNCH A MISSILE . . .

simulate

any dynamic problem!

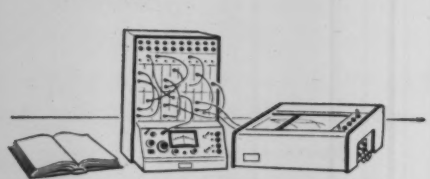
Key factors encountered by a missile in space are being simulated on this PACE Analog Computer. By turning a dial, engineers can study reaction and performance of materials under varying stresses and temperatures.

The PACE Analog Computer is helping industry, science and the military to take the guesswork out of design. With this versatile tool, engineers gain insight into the operation of complicated systems and processes. They obtain an accurate, instant-by-instant picture of performance under dynamic conditions. They can experiment with new ideas and techniques without interrupting normal production, and they can accurately predict safety factors and performance before equipment is built.

To demonstrate the value of analog computers and to aid in solving your complex engineering problems, EAI operates three Computation Centers. Here, experienced EAI analog specialists use the most advanced techniques and equipment in providing sound, workable solutions to your most difficult problems. This Computation Center service is available at a low rental rate. For additional information, write for Bulletin CC-821.

Electronic Associates, the world's largest manufacturer of general purpose electronic analog computers, offers a complete line of analog computing equipment and accessories.
If you would like information on how actual problems were solved with PACE Analog Computers, mention your field of interest and we'll send appropriate literature.

Outstanding career opportunities for engineers with proven ability—résumés invited.



New solid-state computer and desktop X-Y plotter.

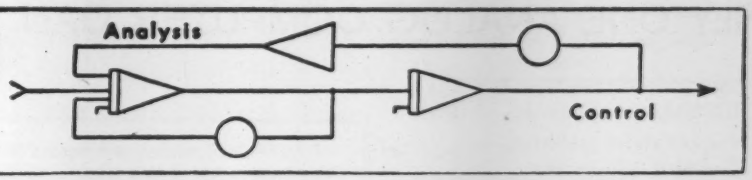
EAI

ELECTRONIC ASSOCIATES, INC.

Long Branch, New Jersey

CIRCLE 88 ON READER-SERVICE CARD

SIMULATION COUNCIL



Newsletter

John McLeod, EDITOR
Suzette McLeod, SECRETARY

8484 La Jolla Shores Drive,
La Jolla, California

Simulations Councils Inc.

Jack Sherman, Lockheed Aircraft Corp., Sunnyvale, Calif.; Chairman, Board of Directors

Jack Sherman

P. J. Hermann

Midwestern Simulation Council

P. J. Hermann, Iowa State University, Ames, Iowa; Chairman, Steering Committee

Western Simulation Council

Ladis D. Kovach, Douglas Aircraft Co., El Segundo, Calif.; Chairman, Steering Committee

Eastern Simulation Council

William F. Blodgett, Electronic Associates Inc., Long Branch, New Jersey; Chairman, Steering Committee

Southeastern Simulation Council

M. E. McCoy, Martin Company, Orlando, Florida; Chairman, Steering Committee

Central Simulation Council

Ted Williams, Monsanto Chemical, St. Louis, Missouri; Chairman, Steering Committee

Ted Williams

Maughan Mason

Rocky Mountain Simulation Council

Maughan S. Mason, Thiokol Chemical Corp., Brigham City, Utah; Chairman, Steering Committee

DDA Council

Rudolf Rutishauser, Litton Industries, Canoga Park, Calif.; Secretary, Board of Directors

Bits

The *Newsletter* this month is lengthy, **Bits** will be correspondingly brief:

PIECES: **Southeastern Simulation Council**

"Calculation of Microwave Antenna Radiation Patterns by the Fourier Integral Method," Wayne K. Rivers Jr.

"The Interconnection of Remotely Located Analog Computing Equipment," W. C. Bennett

"An Automatic Blood Flow Resetting Integrator," Andrew Spear

Rocky Mountain and Western Simulation Council (joint meeting)

"Iterative Differential Analyzer Function and Control," Max Gilliland

"Two-level Correlation on an Analog Computer," C. L. Becker and J. V. Wait

Discussion on the "Role of Analog Computers in Engineering"

Information on the Analog Computation Lab of the University of Arizona.

Midwestern Simulation Council

"Continuous Data Analysis with Analog Computers Using Statistical and Regression Techniques," Art Rubin

"Improved Transport Delay Circuits for Analog Computer Use," W. J. King and V. C. Rideout

ANALOG TECHNIQUES: Circuits from "The Use of Silicon Junction Diodes in Analog Computation," R. M. Howe

LETTERS: From Jack Sherman and Lee Cahn also

Several *He-Wents*, some *Info* and *SCI Activities*.

Pieces

SOUTHEASTERN S/C MEETING OF 27 JAN. ON ANTENNA PATTERNS, COMPUTER INTERCONNECTION AND BLOOD FLOW

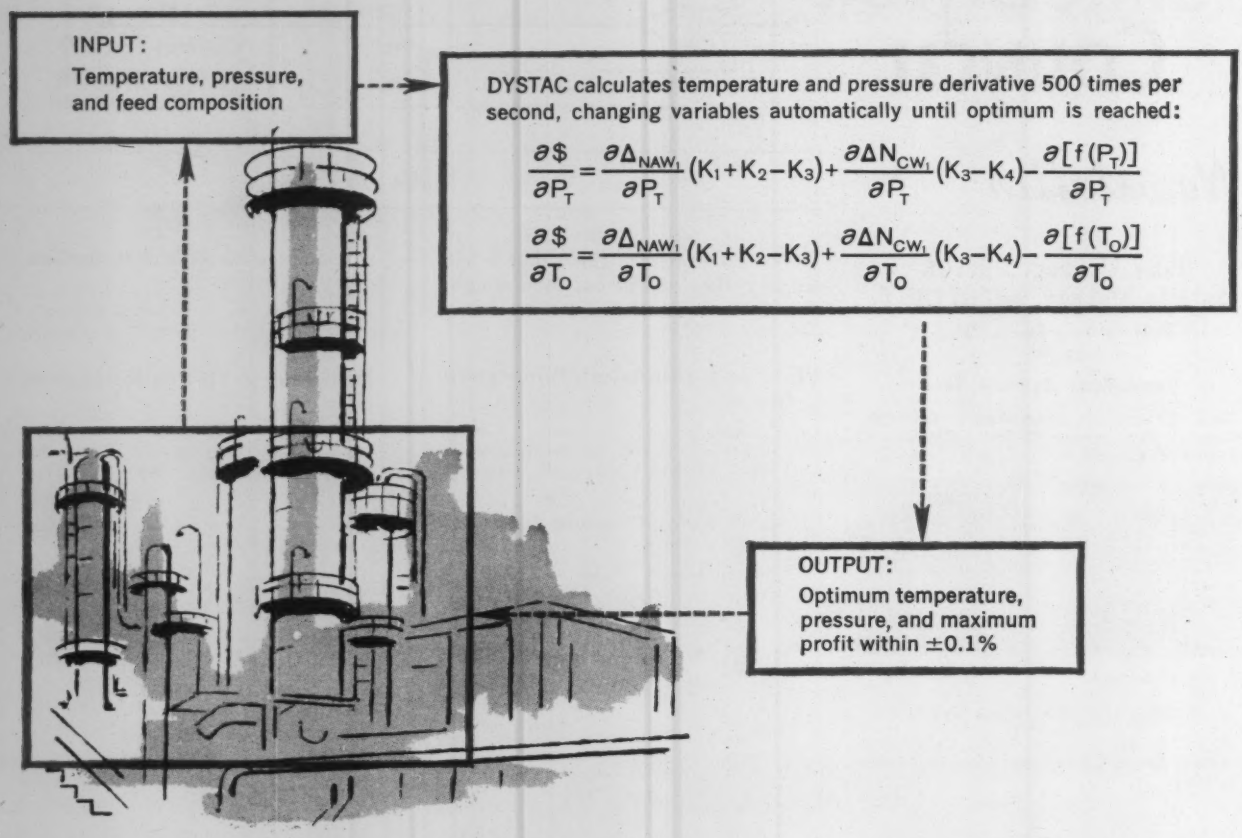
The Georgia Institute of Technology, represented by **Bob Johnson**, and Scientific-Atlanta Inc., represented by **W. H. Bradley**, were co-hosts on the January 27th meeting of the Southeastern Simulation Council in Atlanta. **Jim Tootle** (Martin Company, Orlando, Fla.), Secretary of the Southeastern Council, has sent us a copy and a condensation of one of the papers presented, and an "Essay" on "Calculation of Microwave Antenna Radiation Patterns by the Fourier Integral Method" by **L. Clayton Jr.** and **J. S. Hollis** (both of Scientific-Atlanta Inc.), which was presented in part at the meeting by **Wayne K. Rivers Jr.** (Georgia Tech). Jim also sent us his own description of Rivers' presentation and an abstract of another paper "An Automatic Blood Flow Resetting Integrator" by **Andrew Spear.** We give you herewith the condensation, description, and abstract, and suggest that if anyone is interested in more details, copies can be obtained from the authors (Scientific-Atlanta, 2162 Piedmont Rd., N. E., Atlanta 9, Ga.).

Rivers on Antenna Radiation Patterns

"Very basically (my condensation, that is!)" writes Jim, "Rivers discussed the work that had been done at Georgia Tech in the development of the unit being sold by Scientific-Atlanta as the Model CF 1 Fourier Integral Computer.

"In designing a microwave antenna, the engineer generally assumes a reliable set of antenna conditions, and the radiation pattern is calculated, or a prototype is made and the radiation pattern is measured.

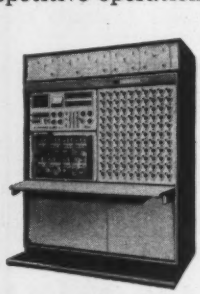
ONLY ONE ANALOG COMPUTER CAN DO IT:


INPUT:
Temperature, pressure, and feed composition
DYSTAC calculates temperature and pressure derivative 500 times per second, changing variables automatically until optimum is reached:
$\frac{\partial \$}{\partial P_T} = \frac{\partial \Delta_{NAW_i}}{\partial P_T}(K_1+K_2-K_3)+\frac{\partial \Delta N_{CW_i}}{\partial P_T}(K_3-K_4)-\frac{\partial [f(P_T)]}{\partial P_T}$
$\frac{\partial \$}{\partial T_O} = \frac{\partial \Delta_{NAW_i}}{\partial T_O}(K_1+K_2-K_3)+\frac{\partial \Delta N_{CW_i}}{\partial T_O}(K_3-K_4)-\frac{\partial [f(T_O)]}{\partial T_O}$
OUTPUT:
Optimum temperature, pressure, and maximum profit within ±0.1%

5800 DYSTAC® Iterative Analog Computer Optimizes Chemical Processes On-Stream!

High-speed repetitive operations and dynamic memory give DYSTAC the power to solve these simultaneous equations so rapidly and accurately you can use it for on-stream optimization! The reaction in this problem is a two-stage, constant pressure one. Typical solution time using the 5800 DYSTAC iterative computer is one minute.

The 5800 DYSTAC Iterative Analog Computer is unique, combining the advantages of analogs with those of digitals. It solves equations, such as those shown above, simultaneously in high-speed repetitive operation (up to 500 solutions per second) as well as in real time. Its dynamic memory permits direct plotting from high-speed repetitive operation without rescaling. It can store data or continuous functions, start and stop its program by comparing new results with memorized information, reinsert data or functions during calculations, and time-share computer components. In addition, DYSTAC can be used as the most accurate general-purpose analog computer ever built.



Whether your interests lie in process optimization, structures, operations research, aerodynamics, missile tracking, or any of many other areas, the 5800 DYSTAC Iterative Analog Computer offers unprecedented computer capability. A detailed report, #0003, "Correlation and Optimization Using DYSTAC", is available on request. For a copy, or more detailed information on DYSTAC, simply write or call.

Computer engineers with analog and digital backgrounds, who wish to explore the many professional opportunities available, are invited to send resumes.

COMPUTER SYSTEMS, INC., Culver Road, Monmouth Junction, N. J. • DAvis 9-2351

A Schlumberger Subsidiary

CIRCLE 89 ON READER-SERVICE CARD

Rivers discussed the development of the Fourier Integral Computer, which uses the well-known Fourier-integral technique of calculating the radiation pattern from a set of assumed, calculated or measured data about the antenna under design."

The Interconnection of Remotely Located Analog Computing Equipment by W. C. Bennett (Flight Controls Georgia Division, Research Laboratory, Lockheed Aircraft Corp.)

This paper dealt with a problem involving full flight simulation of an aircraft using two computers located approximately one third of a mile apart.

The analog equipment at the Georgia Division, Lockheed Aircraft Corp. is assigned to two areas with a 130-amplifier unit in the Mathematical Analysis Dept. and a 30-amplifier unit in the Flight Controls Research Laboratory. The Research Laboratory became engaged in the investigation of dynamic characteristics of a medium military assault transport involving full computation of the flight equations in six degrees of freedom. This demanded computer capacity beyond that available in the laboratory, and excessive installation charges would have been made had we borrowed extensively from the Math Analysis Department.

Interconnects between the two installations, which are approximately one third mile apart, were provided by six pairs of directly connected telephone lines and one "ring down" line. Measurements indicated both an A.C. and a D.C. potential difference between the computer grounds. Also, co. :derable noise was present on the lines.

Both the problems of potential differences and noise were solved by transmitting both the signal and its ground from one computer to the other and differencing the two in the second computer. Thus, signal e_s relative to g_1 is generated in computer No. 1. In computer No. 2 the voltage difference ($g_1 - g_2$) is generated and inverted, then summed with voltage ($e_s - g_1$). The resulting output is $-e_s$ relative to g_2 which is the desired signal. In addition, since noise introduced on each line is essentially identical, the differencing eliminates the noise also.

The capacitive load represented by the lines caused some amplifier oscillation, but a 0.001-microfarad feedback capacitor was sufficient to eliminate it and caused no significant phase shift at frequencies of interest.

An Automatic Blood Flow Resetting Integrator by Andrew Spear

A resetting integrator was described for transforming blood flow into the volume of blood delivered per stroke.

The circuit uses a Miller integrator into which the signal is capacity coupled. The capacity has no resistor return but is clamped to the output at that instant during the cycle when the integrand is assumed to be zero. At the same time the input resistor to the Miller integrator is shorted, thus discharging the capacitor and returning the output to zero.

Another feature of the circuit is a differential amplifier input with negative feedback for gain stabilization. Activation of the reset relay is effected by the electrocardiogram.

The circuit requires no zero adjustment during operation and continues to integrate about the assumed zero of the integrand.

But we can't tell you any more because this paper is to be published in the *Journal of Applied Physiology* and can appear only in abstract form in other publications.

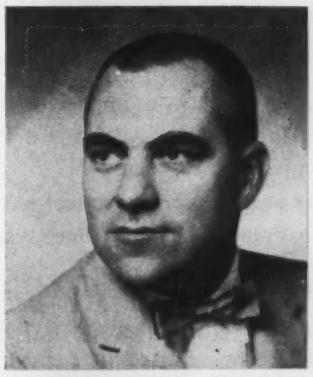
* * *

A tour of Scientific-Atlanta in the afternoon included a demonstration of the computer which Rivers had described. The group also visited the Georgia Tech Radio-Isotopes Laboratory, where a nuclear reactor simulator and a 1-MEV Van deGraaff generator were demonstrated. The afternoon tour ended up at the Georgia Tech Analog Laboratory.

ROCKY MOUNTAIN AND WESTERN S/C JOINT MEETING OF 10 MARCH AT U. OF ARIZONA ON IDA, CORRELATION AND ENGINEERING

Sixty-seven representatives of thirty-eight organizations signed the register at the March 10 joint meeting of the Rocky Mountain and Western Simulation Councils at the University of Arizona in Tucson.

Gilliland on IDA



DR. MAX GILLILAND

We have copies of two of the papers presented, and notes on the discussion and tour arranged for this eminently successful meeting by our host **Granino Korn** (Professor of Electrical Engineering).

"Iterative Differential Analyzer Function and Control" by **Max Gilliland** (Beckman/Berkeley Div., 2200 Wright Ave., Richmond, Calif.) will not be covered in detail here as it is quite long and copies are available on request to the author. Most of this paper also was published in the April, 1961 issue of *I&CS*. However, a part of Max's introduction, which is enlightening and possibly controversial, seems worth repeating verbatim:

"The analog computer has two distinct advantages over the digital computer. These are an ability to integrate and a capacity for rapid problem solution. Although the modern digital machine with large storage capability, high-speed arithmetic units and accompanying problem oriented language is a powerful tool for the evaluation of a specific mathematical model, generally the analog machine is still superior as a design or synthesis tool due to its computation speed and flexibility. Further, as is attested by the existence of a vast literature in the area of numerical analysis, serious problems are encountered with the approximate integration of differential equations using numerical techniques.

"Along with the high accuracy normally required of EDA (electronic differential analyzer) components, a restricted bandwidth has been imposed on the machine. Thus, usually, the EDA is not suitable for the im-

J. A. Baker, Operations Group Manager at one of the Boeing Aero-Space Division's EASE® Analog computation laboratories. EASE reliability (actual records: less than 2% down time over 6,592 scheduled hours—20 hours/day, 6 days/week, 44 weeks) helps assure Boeing of meeting commitments on time.

RESEARCH LEADERSHIP

Speeds the Dyna-Soar Program at Boeing

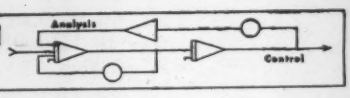
Established leadership in research—so important in the selection of the Boeing Company as system contractor for the U. S. Air Force's Dyna-Soar—is playing an even more vital role as the company carries the program forward. For this vast undertaking—considered "the first step towards practical man-in-space flight"—involves new and complex problems that only the most advanced research can solve.

Making important contributions to the Dyna-Soar design and simulation program is the Beckman EASE Analog Computer facility—one of three EASE installations Boeing uses in research and development activities at Aero-Space Division for Minuteman, Bomarc and hydrofoil programs, and at Transport Division for 707 and 720 jetliner projects.

Beckman® INSTRUMENTS INC.
BERKELEY DIVISION
RICHMOND, CALIFORNIA

C-19

CIRCLE 90 ON READER-SERVICE CARD



plementation of statistical studies. Some analog manufacturers provide a machine with considerable bandwidth to satisfy this and similar requirements. However, a decrease in computation accuracy accompanies an increase in bandwidth. Consequently, the same machine generally cannot serve both purposes.

"In the past, analog computation has suffered from the requirement for redundant non-linear hardware, and more important, the inability to utilize iterative or numerical techniques. Recently a new electronic differential analyzer with a repetitive-operation mode has evolved. The inclusion of an additional element, the inverse or complementary integrator, as well as more sophisticated control logic, has significantly increased the efficiency of hardware usage and expanded the simulation capability of the machine. Both incremental and continuous computation techniques can be used simultaneously. With the improved control capability both standard and extended bandwidth computation equipment can be used together in the same machine. The inclusion of broad-band equipment is of vital importance if maximum utilization of numerical or hybrid techniques is to be realized. The features outlined above largely obviate the past computational limitations of the EDA.

"The new machine can be called appropriately the IDA (iterative differential analyzer). The IDA retains all the previous advantages of the EDA, in addition to its ability to function as an analog version of a digital computer. Essentially, a hybrid (analog-digital) mathematical models may be utilized to describe physical problems. The purpose of this article is to explain the features of the typical IDA, and in some detail, how its hardware provides this new capability."

Max proceeds to accomplish this stated purpose and concludes: "The control characteristics of a typical IDA have been described in some detail. With these features the IDA has become the most sophisticated and flexible analog computer developed. Because of its vastly improved computation capacity, the range of applicability of the IDA has been greatly enhanced. Not only will primary users of analog equipment—such as the aircraft and missile industry—avail themselves of this new type of equipment, but other industries will become increasingly interested and aware of the inherent usefulness of the IDA."

During the discussion period the following hastily scribbled note was passed to your Ed:

"When you write up Gilliland's talk how about gently chiding him (and EAI by extension) for not giving credit to CSI for the pioneering work they have done with DYSTAC?" The initials on the note *might* have been J.E.S.!

Becker and Wait on Two-Level Correlation

We also have a copy of ACL Memo No. 21, "Two-level Correlation on an Analog Computer" by **C. L. Becker** and **J. V. Wait** (University of Arizona), with a note which reads in part: "This paper is presently being submitted for publication to the IRE PGEC. Therefore, it is requested that only the Abstract be published in the Newsletter at this time." So we will do just that!*: It has been known for some time that an approximate correlation analysis of a random process can be performed using quantized values of the signal. The simplest form possible is a two-level correlation, wherein merely the polarities of the process at two sampling times (T_1 and $T_2 = T_1 + \tau$) are compared. This report describes a study of this technique, using analog computer circuitry, and is an interesting example of how existing electronic analog computers can implement essentially digital functions in making accurate statistical measurements.

The Analog Computer in Engineering

The following notes on the discussion "The Role of Analog Computers in Engineering" are the result of a joint effort by **Bill McLean** (North American Aviation Inc., Los Angeles 45, Calif.) and **Hans Meissinger** (Hughes Aircraft Company, Culver City, Calif.).

"I contacted **Walt Karplus** and **Lad Kovach,**" wrote Hans, "To avoid misrepresentation. As for the other three participants in the discussions—**Rajko Tomovic, Howard Tompkins,** and **Granino Korn**—I believe the remarks quoted are sufficiently accurate to obviate additional confirmation."

"Dr. **R. Tomovic** of Belgrade, Yugoslavia, currently guest professor at UCLA, outlined two areas of usefulness of the analog computer in mathematical training:* First, as an aid to visualizing quantitative relations in algebra, analytic geometry, functional analysis, etc., without tedious numerical work by the student and, second, as an aid in understanding important mathematical concepts such as superposition, approximation by power series, representation of periodic phenomena by Fourier series, operations in the complex plane and conformal mapping. He made reference to the repetitive computer as a particularly elegant tool in demonstrating mathematical relationships and in exploring the sensitivity of solutions to variation of parameters. He is concerned with the fact that the modern engineering curriculum must include more and more pure and applied mathematics. Efforts to upgrade the efficiency of mathematical instruction through judicious use of the analog computer as a teaching (and learning)** aid will tend to relieve the difficulty of bringing mathematical subjects in the curriculum in balance with the other subjects to be taught, without creating an impossible burden. (See also his monograph *Calculateurs Repetitives Analogiques*, Masson & Cie, Paris, 1958—Ed.)

"Dr. **Howard Tompkins,** currently on leave of absence from the Moore School of Electrical Engineering, University of Pennsylvania, and teaching at the University of Mexico, at Albuquerque, elaborated further on the use of teaching aids which, in the case of mathematics, would be the analog computer. He made a clear differentiation between this concept and that of using the (digital) computer as the controlling element of an automatic teaching machine of many (including non-mathematical) subjects. (Such a machine was displaced at the WSC meeting held at System Development Corporation on January 10th.—Ed.) He emphasized that for an efficient learning process

*In case the paper has not been published by the time you read this, or in case you do not have easy access to the *IRE PGEC*, copies of this (and other ACL Memos—list on request) can be obtained by writing the University of Arizona, Tucson, Department of Electrical Engineering, attention Dr. G. A. Korn.

*They are widely used in Russia for teaching math, he said.—Ed.

**And prosthetic tool. You should see, as we did, his artifical hand! More about that later.

the pupil should hear as well as read about his subject. On the average, however, he retains less than half of the information presented to him. To increase retention he must then do problems in order to apply his active knowledge of the subject. Finally he should use some aid (a computer) to illustrate the problem to gain a maximum of retention. An important aspect, often neglected by instructors, is the "reward principle" in education. The instructor should return students' papers as rapidly as possible to maintain their interest in the subject and their retention of information, a most important feedback function in the learning process. This feedback can also be strengthened by using the computer as a teaching aid, to confirm the student's answer to a problem.

"**Dr. Walter Karplus** (UCLA), **Dr. Ladis Kovach** (Pepperdine College and Douglas Aircraft Company) and **Dr. Korn** followed with comments from the floor, projecting a wide spectrum of opinions on teaching by computer. **Walt Karplus** stated that there are two different schools of thought, one that would place a strong reliance on early use of the computer in engineering education to make life easier for the student in solving complex problems, and the opposite view that this entails a potential danger, namely the use of the computer as a short-cut for thinking.* The possibility of missing an important point or concept and not being trained for circumspection in analysis must be guarded against.** When asked what school of thought he favored, Dr. Karplus preferred to be non-committal, but the audience apparently guessed it quite well, anyway. In order not to be misunderstood, he made clear that one must distinguish between computer application in learning and in performing a technical task. There is no question that both analog computers and digital computers are well established as design tools. Their use does not imply curtailment of thought in problem analysis.

"**Lad Kovach** gave a different view: In agreeing with **Rajko Tomovic** that there is so much to cover in the engineering curriculum, he argued that every possible means should be used to bring into the classroom, and demonstrate, the pertinent principles of mathematics and to show how real, physical phenomena differ from the idealizations used in many areas of analysis, e.g. the effect of nonlinearities, additional degrees of freedom of motion, couplings between modes of vibration, etc. Acting as moderator, **Hans Meissinger** added that over-emphasis on idealized mathematical models in engineering training may have the consequence that the student will be so absorbed by the analytical methods of solution as to overlook the limitations of the model and, hence, the limited validity of his analytical results. The computer can serve as an excellent tool to show the student the potential risk of generalizing these results and to teach him an appreciation of solution sensitivity to parameters and conditions assumed in formulating the model. This thought applies not only to graduate engineering courses but should be brought home to undergraduate students as well.

"**Granino Korn** added some comments on the obvious benefits of having electrical engineering students use the computer in the laboratory to gain a fuller understanding of the principles of control system theory, information theory and other basic disciplines. To give the student an appreciation of random processes and their effects on servo systems he considers the analog computer, and in particular, the repetitive computer, the ideal tool. This is precisely what his department and his analog computer facility are trying to accomplish. (See also his remarks as a speaker on the afternoon program in which he described the activities, projects and mode of operation of the analog laboratory).

Hans goes on to say, "This concludes my reconstruction of the 'Computers in Education' debate at the WSC meeting. The lesson to be gained from this exercise is to use a tape recorder and, in addition, have two people take notes during the next great debate which will be held on May 12,* to assure us of better and more authentic coverage. Wisecracks and all."

*Some say they should be used only to demonstrate principles, not to solve problems.—Ed.

**For instance, it is claimed that the development of non-linear theory was delayed because computers could be used to solve the problems.—Ed.

*He was referring to the WSC meeting held in connection with the WJCC where they did try just that. But we understand the two note-takers were leaning heavily on the recorder, which must in turn have been depending on the note-takers, 'cause we got a frantic call from our host George Bekey (who had planned to report the meeting) for our notes. Nobody could read mine, but maybe Suzy's helped. We await George's report with interest.—Ed.

Korn on U of Arizona

Granino supplied us with the following information concerning the University of Arizona's ACL (Analog Computation Lab), which we visited to witness interesting demonstrations. (A detailed description also appears in the Sept. 1960 issue of *I&CS*, pages 1551-52.)

DR. GRANINO KORN

The Laboratory's Ph.D program in Electrical Engineering is concerned with the use of analog computers for statistical studies of control systems and communications. The first Ph.D. thesis project has been started; a second project deals with incremental digital computation using a new type of arithmetic.

A computer installation specifically designed for the dual purposes of instruction and analog computer development has only a small number of operational amplifiers and four electronic multipliers, but it comprises a modern push-button control system, digital read-out, and individual control of integrators for automatic programming. The machine may be used either as a single computer or as a pair of smaller machines, and the instructor can connect various external equipment into the students' plug-in patchboards by means of patching connections on special transfer patchbays. The machine is suitable for multi-shift operation with interchangeable plug-in patchboards.

A student's plug-in patchboard especially developed for teaching purposes, with plug-in resistors, capacitors, potentiometers, and diodes permits one to patch many standard or special computing circuits including

newly developed fabricated diode circuits. A plug-in joystick* permits each student to build up a small flight simulator; the computer oscilloscope functions as an artificial horizon. These patchboards permit especially flexible use of plug-in components and are used extensively for computer circuit design as well as for computation.

Plug-in integrating and summing networks transform patchboards into committed patchbays which afford good practice in the use of analog computers with "committed" amplifiers. Most patching connections are made with convenient shorting links rather than with long patchcords, and a problem setup closely resembles a textbook block diagram.

There is also a small analog computer mounted on a wheeled table to serve for class demonstrations with a large display oscilloscope. It can also be slaved to one of the larger computers to provide additional capacity.

The University's "Beckman Project," a 50-amplifier analog computer under construction, combines Beckman/Berkeley amplifiers and Electronic Associates servos (donated by their manufacturers) with a new patchbay provided by Tucson businessmen and a student-designed push-button control system. A second-year graduate student is the project supervisor.

Some new precision limiters and switching circuits developed at the University of Arizona include a *precision limiter* capable of limiting at any desired level, an accurate *dual limiter* which can be used as a switch, an accurate *timer* or *voltage-to-time-to-digital converter*, and a new multivibrator circuit capable of producing very accurate pulse and triangular wave shapes.

In a new electronic multiplier of the triangle-integration type, a voltage-controlled double precision limiter clips a biased 5 to 10 kc triangular waveform. Averaging of the clipped triangles permits squaring and thus quarter-square multiplication with a static accuracy better than 0.2% of full-scale. Only two operational amplifiers and six diodes are used together with a two-tube triangle generator shared between four multiplier channels. This, Granino believes, is the most inexpensive multiplier of comparable accuracy.

Other University of Arizona devices included an accurate *sample-hold circuit* used for readout and statistical computations with repetitive analog computers, and a new electronic *slicer circuit* which emits pulses when the input waveform is between two specified "slicing levels" $X - \Delta X/2$ and $X + \Delta X/2$. This circuit is useful for servo-error computations, but its main application is to gate a counter in an amplitude-distribution analyzer which yields accurate estimates of probability density.

To obtain faster switching and more accurate repetitive computation, they have developed new *plug-in operational amplifiers* which may be used singly or in cascade to permit analog computation at frequencies as high as 0.5 Mc.

For statistical studies by the GPS Laboratories Monte-Carlo technique, a repetitive analog computer repeats random-input solutions of the system equations 10 to 20 times per second.

This machine is now in the development stage. Engineering is done in the winter, construction (with graduate student in *sole* charge) in summer. It will be finished in September and debugged by Christmas. "We will, however, *simulate* it here and now—just like a moonshot before the booster is ready!" said Granino.

A complete electronic analog computer built from modified commercial components by two undergraduate students supervised by a graduate assistant also was shown.

*!!—Ed.

MIDWESTERN S/C MEETING OF 13 MARCH ON STATISTICAL TECHNIQUES AND TRANSPORT DELAYS

Thanks to **Robert T. Harnett** (Wright-Patterson Air Force Base, Ohio), Secretary of the Midwestern Council, we have more info on their meeting of 13 March at the Institute of Science and Technology, University of Michigan, than we can possibly publish. However, we will try here to give you an idea of the subjects covered, and will also see if we can publish some of the more pertinent articles in their entirety in either the Special February Issue of *IRETEC* (Institute of Radio Engineers, Transactions on Electronic Computers) of which your Ed is Guest Editor, or one of the subsequent issues of which **Jack Sherman** is Editor for Analog and Combined Simulation papers.

After the welcoming address by Dr. **Rune L. Evaldson,** Associate Director of the Institute, **Bob Howe** (University of Michigan, Ann Arbor) presented "The Use of Silicon Junction Diodes in Analog Computation."

Howe on Silicon Junction Diodes

As usual, Bob had so much of interest to say, both in his talk and in the discussion that followed, that we would like to print it all here and now. However, in line with our announced policy of no complete technical papers in the *Newsletter* we must pull a shenanigan: We will publish the nucleus of Bob's info as circuits under *Analog Techniques*. If this isn't enough, we refer you to the author for the full whammy. (Dr. Robert M. Howe, Dept. of Aeronautical and Astronautical Engineering, University of Michigan, Ann Arbor.)

Rubin on Statistical and Regression Techniques

The next paper, "Continuous Data Analysis with Analog Computers Using Statistical and Regression Techniques" by **Arthur I. Rubin** (Princeton Computation Center of EAI, Princeton, New Jersey) stops us completely; it defies condensation (by this Ed. anyway). I will therefore simply tell you what he covered, and let those who are interested check the source. Art defines, gives the math, diagrams the circuits for computing, and explains: Variance; Mean; Autocorrelation (and the necessary Padé approximation); Cross Correlation; Fourier and Power Spectrum Analysis; and Regression (with the necessary "least squares" circuit). With a brief bibliography, this is a paper well worth ordering by those working in this area. However, if you do request it you should also write to your Ed for a copy of the discussion that followed; it is pertinent, and Harnett did a good job of filling us in on it.

King and Rideout on Transport Delay

Another paper forwarded from this meeting is "Improved Transport Delay Circuits for Analog Computer Use" by **W. J. King** (formerly Uni-

versity of Wisconsin, now Allis-Chalmers Mfg. Co.) and **V. C. Rideout** (University of Wisconsin and Allis-Chalmers Mfg. Co.). This paper also is too long and technical for the *Newsletter* but, because of its importance, we give you here the introduction so that you will know what is covered, and some comment.

"In analog-computer studies of problems such as control systems for chemical and nuclear plants it is often desirable to get pure delay of a signal. That is, given $f(t)$, the delay signal $f(t-\tau)$ may be required. Techniques for obtaining such signals are referred to as the simulation of "dead time" or of "transport delay" or "transport lag."

In many cases the problem is rendered still more difficult by the requirement that the delay τ be some function of time, $\tau(t)$. This is necessary in some correlators, for example, and in problems where the flow rate in pipes is variable.

The various schemes that have been used in the analog simulation of transport delay may be classed as follows:

(1) Magnetic tape or drum systems.
(2) The lumped-parameter passive delay line.
(3) The "bucket-brigade" delay line, using a large number of small storage capacitors and switching devices.
(4) Curve follower schemes.
(5) Linear circuit approximations to an ideal delay, such as the Padé approximation, realized with ordinary electronic differential analyzer components.

Of these various systems the magnetic tape and drum systems suffer from mechanical complexity and high cost, but can provide the greatest precision and flexibility. Passive delay lines, because of the inductors required, are limited to short delays, of the order of milliseconds, and are thus to be preferred for high-speed analog computation only. Also, variable time delay is quite difficult with such delay lines. The "bucket brigade" delay line requires a large number of stages and rapid switching if granularity is to be avoided, but has some attractive features, and has been successfully applied.

Curve follower schemes, in which $f(t)$ is recorded and read off later as $f(t-\tau)$ by use of a manual or automatic curve-follower, have been successfully used, and are attractive because of their simplicity of conception. They have the disadvantages in speed, precision and maintenance common in such mechanical devices.

The linear network delay circuit approximations, which may be realized with operational amplifier circuits, have found favor in the past, despite poor transient response of the all-pass networks most often used. Their popularity appears to be based on the possibility of their realization with ordinarily available equipment, and their flexibility. They may, for example, be readily adapted to any time scale, and variable time delays can easily be obtained by incorporating servo or other multipliers.

In this paper some new results in the design of linear circuit approximations to an ideal transport delay will be described."

They were described by considering the "Padé Approximation Method"; a "Realization of Padé Approximation with Analog Computer Circuits"; "Step Response of the Padé Approximation"; "Time Domain Synthesis of an Improved Delay Circuit"; and Time-Variable Transport Delay." Computer diagrams, plots, recordings, and a 15-title bibliography make this a comprehensive paper. Again, those interested enough to request a copy from the author (Electrical Engineering Dept., University of Wisconsin, Madison, Wis.) should write this Ed. for a copy of Harnett's writeup of the discussion.

T. C. Anderson, the original and until now only contributor to this section of our *Newsletter*, has sent in an interesting contribution, "Pulse Circuit," for this month's *Newsletter*. But it seems to us that **Bob Howe's** presentation at the March 13th meeting of the Midwestern Simulation Council also falls within this category. So we will give Anderson a rest; those interested in the "Pulse Circuit" (and "Setting of Integrator Capacitors," another Anderson contribution that we haven't published yet) will just have to check future *Newsletters*. "Here's Howe"!:

Analog Techniques By Robert Howe

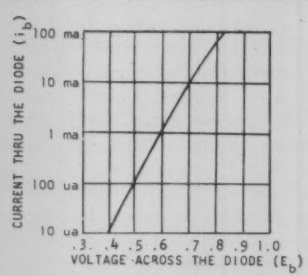


FIG. 1

Fig. 1 shows typical current-voltage characteristic of a silicon junction diode at room temperature.

Fig. 2 shows silicon diode performance in an amplifier circuit.

Fig. 3a is a limiting circuit. Gain is unity. Saturation level $\pm v_s$ is varied by adjusting Pot 1. Symbol Z in box represents two back-to-back Zener diodes.

Fig. 3b is a limiting circuit. Gain

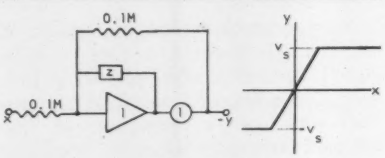


FIG. 3A

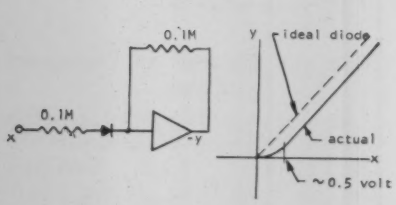
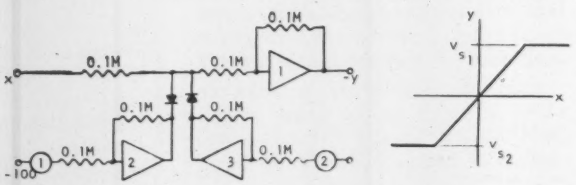


FIG. 2

FIG. 3B



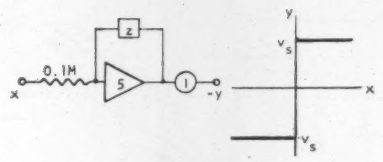


FIG. 4

is 0.5 (unless 0.2 meg feedback resistor is used). Amplifier 1 can be used to sum other voltages. Pot 1 adjusts v_{s1}, Pot 2 adjusts v_{s2}. Output of amplifiers 2 and 3 can be replaced by potentiometer outputs, but limiting is soft due to finite pot output impedance.

Fig. 4 is a bang-bang circuit. Pot 1 adjusts the output magnitude $\pm v_s$.

Fig. 5 is a dead-zone circuit. Pot 1 adjusts e_1, pot 2 adjusts e_2. Note the use of the "catcher" diodes D2 and D4 to prevent back biasing of D1 and D3 when not conducting. This greatly speeds diode recovery time.

Fig. 6 shows dead-zone with limiting. Pot 1 adjusts e_1, pot 2 adjusts e_2, pot 3 adjusts v_s.

Fig. 7 shows a half-wave rectifier. This circuit is extremely accurate.

Fig. 8 shows absolute value. This circuit is also extremely accurate.

Fig. 9 shows a flip-flop circuit (bang-bank with hysteresis). The setting of Pot 1 controls $\pm v_s$. Pot 2 then adjusts $\pm e_1$.

Fig. 10 shows a square-wave and triangular-wave generator. Pot 1 adjusts the amplitude, pot 2 the frequency, pot 3 the duty cycle.

Fig. 11 is an on-off gate. The gate signal g can be derived from a bang-bang circuit such as shown earlier. A precision inverter yields $-g$. For switching of x signals ranging from -100 to $+100$ volts, the magnitude of g should be greater than 100 volts, say ± 120 volts. Note that the exact magnitude of g is not important, as long as the $-g$ input is precisely the negative of the $+g$ input, as insured by a precision inverter to obtain $-g$ from $+g$.

Fig. 12 is a two-position switch.

Fig. 13 is a sample and hold circuit. For $g = v_+$, $y = x$ (0.02 or 0.002 sec time constant). For $g = v_-$, y holds previous x value.

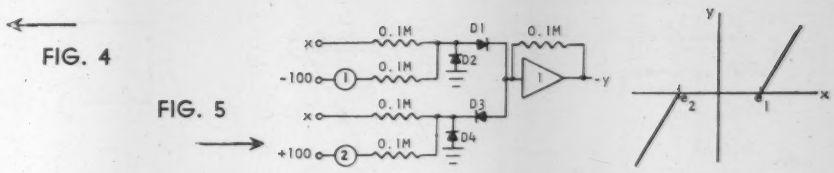


FIG. 5

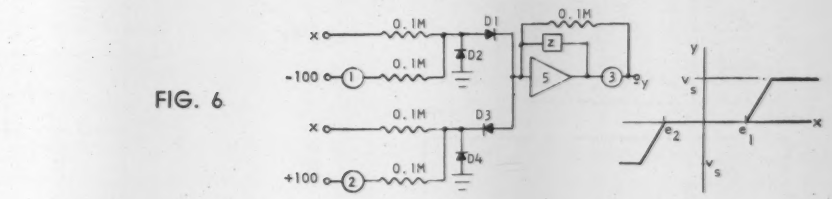


FIG. 6

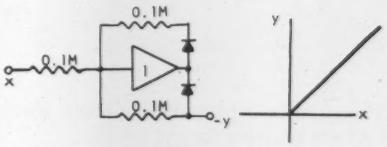


FIG. 7

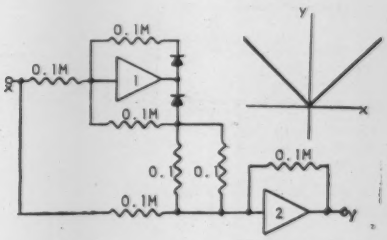


FIG. 8

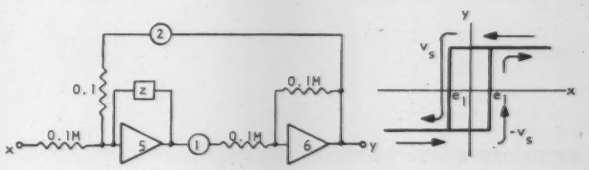


FIG. 9

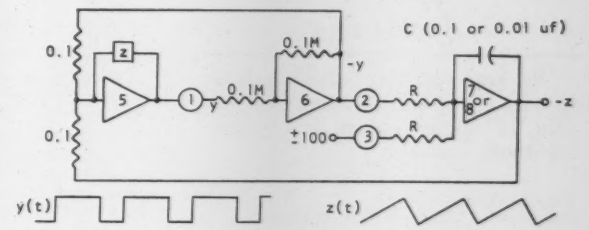


FIG. 10

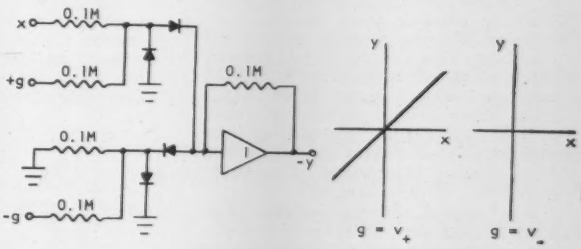


FIG. 11

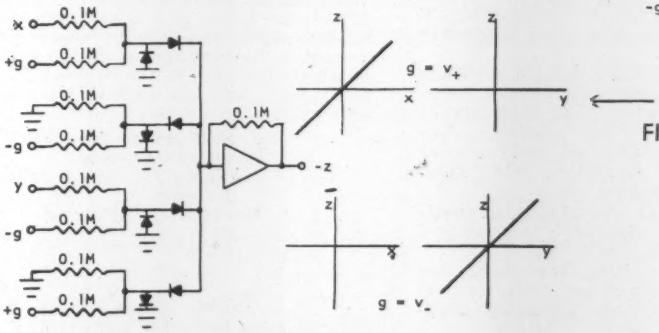


FIG. 12

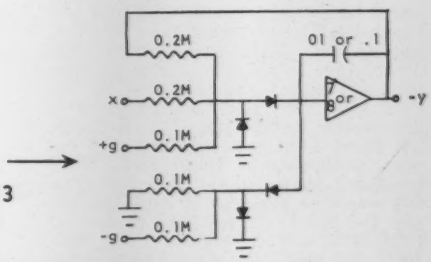


FIG. 13

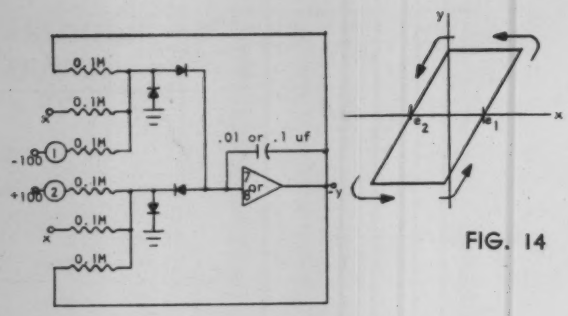


FIG. 14

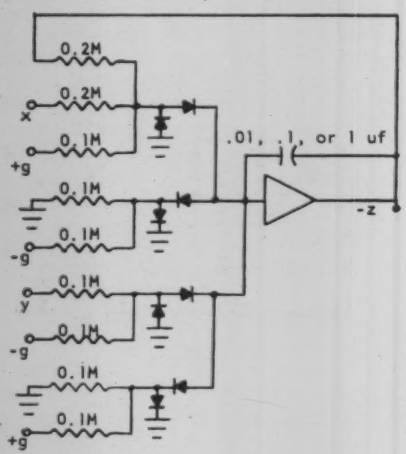


FIG. 15

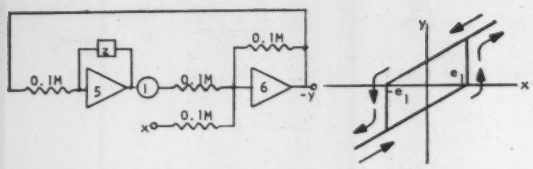


FIG. 16

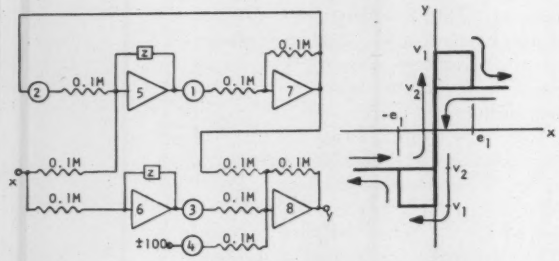


FIG. 17

Fig. 14 is a hysteresis circuit. Pot 1 adjusts e_1, pot 2 adjusts e_2.

Fig. 15 is a reset or integrate circuit. For $g = v_+$, $z = x$ (0.002, 0.02, or 0.2 sec time constant). For $g = v_-$, $Z = (1/RC)\int y\,dt$; ($RC = 0.001$, 0.01, 0.1 sec).

Fig. 16 is a negative deficiency (overlap). Pot 1 adjusts $\pm e_1$.

Fig. 17 shows combined starting and coulomb friction. Pot 1 adjusts $v_1 - v_2$, Pot 2 adjusts $\pm e_1$, pot 3 adjusts $v_1 + v_2$. Pot 4 adjusts the magnitude of y for x e_1 to be equal to $-y$ for x e_1. This may be necessary if the back-to-back zener diodes are perfectly matched.

Speaking of feedback—which we weren't—some of these circuits should produce it!—Ed.

Letters

We give you the following letter without comment, because we feel sure the opposition are just gathering their ammo!

The Editor
Simulation Council Newsletter

At the May meeting of the Western Simulation Council there was a lot of discussion on the future of analog computing. The comparative growth of the fields of analog and digital computing was discussed at some length. Many people pointed out that the field of digital computing has grown at a much faster rate than the field of analog computing. The question arises: Why is this so?

I think one of the reasons this is so is that analog computers have not improved as rapidly and as dramatically as have digital computers. Ten years ago the only digital computer that the Lockheed Missiles and Space Division had was an IBM Card Programmed Calculator. This digital computer was soon out-moded and replaced by an IBM 650. Next Lockheed obtained a Remington Rand 1103. The Remington Rand 1103 was modified and became a Remington Rand 1105. Next Lockheed obtained an IBM 704. The 704 was soon replaced by an IBM 709, and the 709 has given way to several IBM 7090's. The original CPC, 650, 1103, 704 and 709 have all been made obsolete by the advances in digital computer technology as exemplified by the IBM 7090.

In contrast, Lockheed Missiles and Space Division still possesses and operates every electronic analog computer that it has ever procured. Why? The reason is simple. Because the very latest computers which are available today are not significantly superior to the ones which we obtained seven or eight years ago. I feel that if the analog computer manufacturers would do as good a job on improving their product (through research and development) as the digital manufacturers have done, we would now have available some of the following features:

1. A completely transistorized computer with the dynamic range of ± 100 volts.
2. A stabilized DC amplifier with the frequency of the AC stabilizing amplifier in the megacycle region (by means of electronic choppers).
3. A stabilized DC amplifier with a forward loop gain two or three decades larger than it is now.
4. A stabilized DC amplifier with the signal-to-noise ratio several orders of magnitude better than those available today.
5. Electronic multipliers compatible with amplifiers as described above.
6. Arbitrary function generators that are more convenient to set up than those presently available.
7. Complete high-precision computing systems. (.01%) with a bandwidth in the megacycle region.
8. A computing system which has the flexibility of a patch board without the vagaries and reliability problems of the present patch board systems (i.e. replace the patch boards with a relay **matrix).**
9. Increase reliability of present computing systems by one or two orders of magnitude.
10. XY plotters with a very much higher dynamic range, but retaining the same precision of those available today.

I do not claim that this is a definitive list of shortcomings of present-day analog computers, and I invite other readers to add their suggestions to this list. I also throw down a challenge to the analog computer manufacturers to either fish or cut bait. All I hear lately is moans from the vendors that the analog computer market is not expanding at the rate at which they would like to see it expand. Well, here are some of the reasons why!

J. E. Sherman, Manager
Analog Computing
Lockheed Missiles & Space Division
Sunnyvale, California

* * *

Here is Bruno Ulrick's letter we did not have room for last month:

Editor, S/C N/L:

I attended the Western Joint Computer Conference and the Western Simulation Council meeting held here in Los Angeles two weeks ago. I was particularly impressed with the enthusiasm engendered during the latter meeting's discussion of the subject "What is the Future of Analog Computation." Unfortunately, since this was primarily a panel discussion, time did not permit a larger participation from the sizeable audience which was sufficiently stimulated by many of the aspects touched upon by the panel members. I, therefore, take this means of offering some of my comments on several of the points brought out during the discussion as well as some suggestions of my own.

Inevitably during a topic discussion of this nature, some comparison of analog vs. digital computers seems unavoidable. However, I believe it is realized by all concerned that a "competition to the death" by the two computer fields does not exist, is not necessary nor desirable. Each type of computer, by its very nature, can best perform in a particular area of application; the two types may complement each other in some cases, but there is no evidence that one would replace the other for a long time to come. A trend towards real-time digital differential analyzers to complement and supplement the present analog computers may be indicated, especially in the field of space vehicle simulations where high accuracy in the computation of the kinematics equations is required. This, then, leads me to the following points of comment:

1. Analog computer checks validity of digital simulation. We were recently asked to check a digital computer solution by means of our analog computer. The problem under simulation required the input of white noise from a noise generator which is easily accomplished on our analog equipment. On the digital computer, however, this noise input had to be simulated by solving a series of equations whose representation of the true noise spectrum was under question.
2. Physical simulation. Most designers and manufacturers of automatic systems find it necessary to include actual physical components in the closed loop system under consideration. The reason for this is: a) it is desired to test the performance of the component under closed loop conditions; b) the mathematical representation of a particular component may be unknown or difficult to obtain as, for example, in the case of a rather complex system component such as an infra-red seeker head. Even if an adequate mathematical model can be synthesized which generally involves functions of several variables, its validity must often be checked by some form of physical simulation. The analog computer, of course, is a "natural" for this type of simulation.
3. I do not believe that analog computer people are inclined to be introverts to any greater extent than those in the digital computer area. The fact that more and more money is being spent in the digital field is simply an outgrowth of "natural selection." The digital computer finds an inexhaustible number of varied applications in the business world where many routine functions such as cataloging, sorting, storing, etc. are to be performed. The digital computer is, of course, a natural in this field and the demand for these types of computations as well as many others in related fields will always be far greater than the demand for computations or simulations where the analog computer can best play its role. (A somewhat analogous situation perhaps exists in the fact that there are many more desk calculators in use nowadays than sliderules and, of course, the sliderule has not been replaced yet. Furthermore, no severe introversive tendencies are discernible by users of the sliderule). It must also be realized, as has been pointed out at the meeting, that the glamor of the digital computer has been overwhelming and over-publicized; e.g., large-scale digital computers used for election predictions and returns, "least square" error mate selection techniques by means of computer used on television programs, etc. The public, actually, doesn't know the difference between one type of computer or the other but is awe-stricken by the term "electronic brain."
4. I am in complete agreement with Dr. R. M. Howe of the University of Michigan, one of the panel members, on the value and successful use of the analog computer in the field of education. Courses in science or pure mathematics concerned with the solution to all types of differential equations, for example, can be greatly expedited and the student can gain far greater insight into and understanding of the subject matter with the aid of analog computers. I would even go one step further and suggest the possibility that the entire learning process in scientific education from the high school grades through college can be greatly accelerated with the aid of new teaching techniques and motivation in which the analog computer could play an important role. In this age of fierce scientific competition, it is mandatory that steps in this direction be taken without much further delay.
5. Analog computer courses. I propose that analog computer courses be taught free of charge by the various manufacturers of analog equipment to engineers and scientific personnel in industry and government, as well as to school teachers. Mr. R. R. Favreau of EAI tried to justify the tuition charged by his company for these courses by comparing it to comparable rates charged at private institutions of higher learning. It was, however, pointed out that a manufacturer of equipment cannot compare himself to a college or university; therefore, if he chooses to teach courses in analog computers and applications which is, of course, highly commendable, he does so not only from a philanthropic point of view, that of furthering the "state of the art," but actually helps to promote the future sale of his own computer equipment since the course work consists in part of students programming and operating the manufacturer's own analog computer. Thus, tuition charges do not seem to be in order under these conditions, and this is as it should be. Furthermore, I do not believe that it is necessary to tie-up the company's computation center facility while courses are being taught as the theory and underlying principles of analog computation and applications can be taught quite satisfactorily without the use of the computation facility or at most a minimum use thereof. Thus, the computation center would not have to incur a loss for the duration of the course. It may, however, be desirable to make provisions for practical demonstrations and for students operating the computer in the evening which could be effected with minimum disruption of the company's facility.
6. Finally, in order to disseminate information on analog computer theory and its application to many present and future problems in the various fields of scientific endeavor, I suggest that a so-called computer "Peace Corps" be formed consisting of computer experts. These experts would go into the "computer-neglected" underdeveloped areas of industry nationally and internationally, and acquaint and instruct supervisory personnel in the possible uses to which the computer could be put in helping to solve their particular problems. These experts should also be available for consultation and advice to users of analog equipment requiring special techniques, methods, computer circuits, etc. necessary for usual problems and those with extreme accuracy requirements, for example. I believe that computer manufacturers could take the lead in this direction, which should also include giving courses of instruction in the field, at the place of business of the larger concerns, where the demand would justify this effort. This

endeavor, then, should prove to be a most rewarding undertaking in many respects to all concerned.

Bruno Ulrick
Hughes Aircraft Company
Culver City, Calif.

* * *

Not long ago we noticed a reference to the Cahn Instrument Company. We wrote, asking if this was the **Lee Cahn** who used to simulate, and got this reply.

Dear John:

It sure is the same Lee Cahn that used to simulate. Now I make scientific instruments. Some brief literature is enclosed, and a more complete set is being sent separately. As you will see, our main products are a line of electromagnetic microbalances. They are the most sensitive balances made anywhere in the world, and are sold all over the world, including such strongholds of *feinmechanik* as Switzerland, Germany and Sweden. We also make an automatic recording balance, which the scientific world needs real bad, but it is not yet aware of its need.

They are mainly used by medical researchers and other flavors of biochemist, with a scattering of electronics components works, mines (gold ore assay), analytical chemists, rocketship operators (fuel contamination measurements) and others too diverse to list. We have recently started a Data Division (who hasn't?), which unquestionably makes the simplest and least expensive data handling analog computing equipment available for money today.

Lee's address, in case you need a microbalance, is 14511 Paramount Boulevard, Paramount, California.

He Went Thataway!

Jim Rea [charter member, patron —our first $25—the farsighted man who suggested "Simulation" (by any means) rather an "Analog" for our name] to Veep, Radioplane.

Lee Cahn (also charter member) to (see his letter).

Chal Jones (almost charter member—about second meeting) to President, Chalmer Jones Company (Box 1819, La Jolla, Calif.)

Howard Hamer (another of our earliest supporters) to President, Howard Instrument Company (Red Bank, New Jersey).

Our friends do well, don't they?

INFORMATION (Without Theory)

Our files are loaded, but lest we be too, we'll save it till next month!

However, we'd like to announce that copies of the "Proceedings of the Combined Analog-Digital Computer Systems Symposium" (18 papers) and "Proceedings of the 1961 San Diego Biomedical Engineering Symposium" (35 papers) are available from Simulation Councils Inc. at 8484 La Jolla Shores Drive, La Jolla, California at $5 and $10 a copy, respectively.

* * *

We often receive inquiries from organizations seeking qualified personnel for their analog, digital, and —more often now—combined simulation facilities. Less often we hear from qualified personnel. Used to be we mentioned these in the *Newsletter*, thinking they were of interest, and that if they helped get the proper people together, beneficial to the science of simulation in general.

But the Simulation Council Board of Directors feels that some have taken advantage of this "free advertising"* and suggests that the proper procedure would be to purchase space for such from *I&CS* with the stipulation that the ad be placed adjacent to the *Newsletter*. So be it.

* * *

We have received a flyer announcing "Kybernetik-Die Begriffe Nachrichtenübertragung, Nachrichtenverarbeitung . . ." (oops—wrong place!)

"The concepts of transmission of information, processing of information and automatic control engineering originated within technology and physics. Today, however, these concepts have also found application in the biological sciences. The logical procedures, the methods of experimental and theoretical approaches and the mathematical techniques that are applicable to the physical sciences can often be successfully transferred to the realm of the life sciences. By applying those techniques to sensory and neurophysiological problems new insight has been gained into the principles by means of which organisms handle information. Conversely, physicists and engineers have shown increasing concern for the mechanisms that organisms have evolved in the areas of communication and control. The understanding of these mechanisms may have significant technological consequences as, for instance, in relation to the nature of learning process.

»Kybernetik« would like to cultivate experimental and theoretical findings in the following fields: Information theory; theory of automata; theory of control systems; mathematical fundations of communication theory; sensory process and micro- and macrophysiology of the central-nervous-system in relation to information handling; information handling by organisms (incl. man) and taskoriented groups; mathematical models for communication and control processes in organisms."

This still might be the wrong place, but we don't think so!

*Including guess who!—Ed.

SCI Activities

Announcements Received

Midwestern Simulation Council

10 July 1961; A joint meeting with the IRE Pittsburgh Chapter of the PGEC on "Process Control Developments" at the United States Steel Research Center, Monroeville, Pennsylvania.

Presentations:

"The Application of Process-Control Computers in the Steel Industry" by **W. E. Colman** and **F. Slamar** to be presented by **T. R. Schuerger**, United States Steel Corporation.

"End Point Temperature Control of the Basic Oxygen Steelmaking Process by Means of a Special Purpose Analog Computer" by **N. Simcic** and **W. J. Slatosky**, Jones & Laughlin Steel Corporation.

"Simulation of Extreme Adaptive Control System" by **Dr. R. I. Van Nice**, Westinghouse Electric Corporation

"Slab Reheating" by **Dr. A. H. El-Waziri**, United States Steel Corporation

"Study and Simulation of Continuous Processes on a Hybrid Computer" by **K. H. Bhavnani**, Westinghouse Electric Corporation.

Western Simulation Council

13 July 1961; "Modernization of Computer Facilities" at Space Technology Laboratories, Los Angeles, Calif.

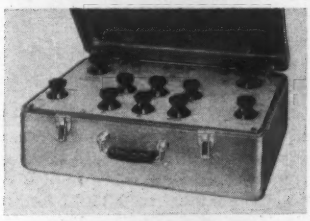
Jerry Reigh of STL and **Gil Grado** of White Sands Missile Range will report on their experience in modernizing their facilities and will discuss technical, economic and other factors leading to the decision to modernize.

Rocky Mountain Simulation Council

Late September 1961: "Analog Computers in an Educational Environment" plus "Medical Applications"; at Brigham Young University, Utah.

ISA Show Preview

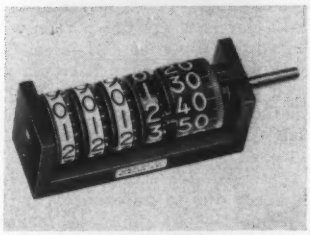
A-C POTENTIOMETER



New H & B Complex A-C Potentiometer is used not only for potentiometric but also for absolute measurements, e.g., for voltages 0.05 to 500 v, currents 0.0005 to 20a, resistances 0.005 to 2 megohms, inductances 2.10^{-5} to 80h, phase angles 0 to 360°, and for capacitances at high voltages (with standard capacitor) one $\mu\mu$f to one μf. Error limits ±0.1%. Bulletin.—*Epic, Inc., 150 Nassau St., New York 38, N. Y.*

CIRCLE 232 ON READER-SERVICE CARD

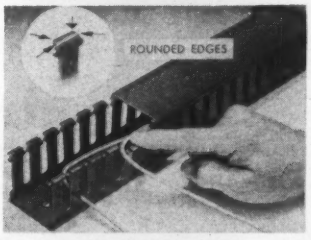
INSTRUMENT COUNTER



New Type "D" Instrument Counter develops high speed digital readings to indicate tool movements within 0.001". Speeds are up to 1500 rpm and readings are attainable at speeds up to 150,000 increments/min. Applicable to machine tools, navigational instruments, tracking instruments, radio wave length indicators, etc.—*Durant Mfg. Co., Milwaukee, Wis.*

CIRCLE 233 ON READER-SERVICE CARD

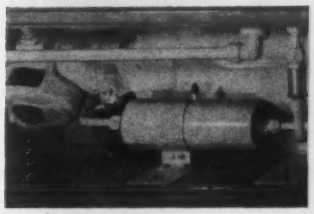
PLASTIC WIRI' G DUCT



New Type E Panduct open-slot Plastic Wiring Duct incorporates rounded top surfaces for protection of wire insulation. Molded from tough, non-flammable vinyl plastic, it is easily cut with fine-tooth hand or power saw. Replaces Type B Panduct.—*Panduit Corp., Dept. IPC, 17301 Ridgeland Ave., Tinley Park, Ill.*

CIRCLE 234 ON READER-SERVICE CARD

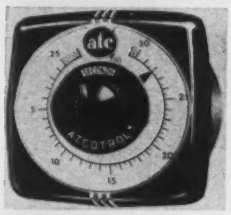
HI-PRESS RIPPLE FILTER



New high-pressure Ripple Filter has no moving parts, contains no elastomer or flexible seals or members, is compatible with all liquids. Unlimited flow ranges, working pressures to 25,000 psi, temperatures −450° to +1000°F.—*Auto-Controls Labs., Inc., 333 S. Hindry, Inglewood, Calif.*

CIRCLE 235 ON READER-SERVICE CARD

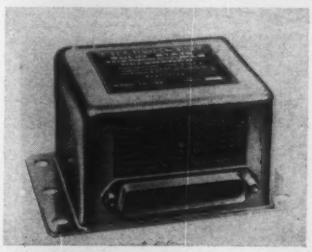
TRANSISTORIZED TIMER



New Series 308 miniature transistorized Timer for time control of laboratory and industrial processes assures up to 500 million operations through use of simple timing network which has no moving parts or tubes, requires up to 50% less power than conventional timers. Transistor permits immediate operation, eliminating warm-up. Load contact rating is 5 amps at 115 volts ac, non-inductive (should be arc-suppressed).—*Automatic Timing & Controls, Inc., King of Prussia, Pa.*

CIRCLE 236 ON READER-SERVICE CARD

T/C REFERENCE JUNCTION



New Thermo-Ref miniature, solid-state, electronic Thermocouple Reference Junction provides constant reference temperature of 100°C (±0.1°) with 10-channel uniformity of ±0.1°C. Channel-to-channel, as well as channel-to-case isolation is greater than 100 Megs at 50 vdc, which eliminates amplifiers or other isolation circuitry. Max power is 1.0 w at 60 or 400 cps.—*Genistron, Inc., 6320 W. Arizona Circle, Los Angeles 45, Calif.*

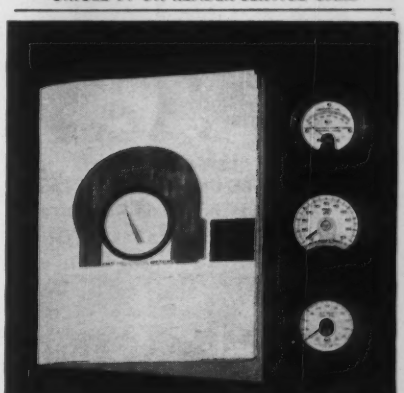
CIRCLE 237 ON READER-SERVICE CARD

DISPLAY NUMBERS, WORDS, COLOR, and SYMBOLS

Ideal for computers, electrical and electronic test equipment, control systems, and annunciation boards. Price complete from $18.00. Write today for complete detailed specifications and quantity prices.

INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
5528 Vineland Ave., North Hollywood, Calif.

CIRCLE 91 ON READER-SERVICE CARD



AMF

PRECISION METERS

Catalog Available

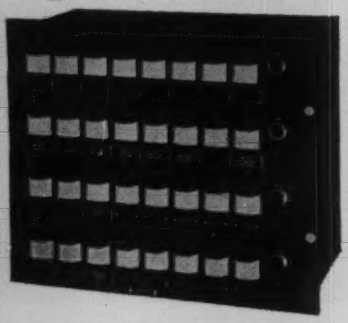
If your operation demands accuracy to 1/10 of 1% you need this AMF Catalog, which includes specifications, sizes and weights of Frequency and Volt Meters for test, research, industrial, military and government use.
AMF Meters are rugged. They compensate for practically any temperature and environment. They can be tailored to your requirements—or are available immediately from stock. Send today for your Catalog! Address Department F

American Machine & Foundry Co.
1101 N. Royal Street, Alexandria, Virginia

CIRCLE 92 ON READER-SERVICE CARD

ANNUNCIATORS
and Accessories

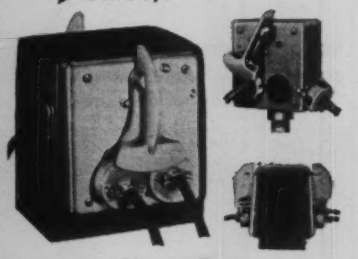
Imagineered by
TEL-ALARM



"UNITIZED CONSTRUCTION"
FOR EVERY PURPOSE

Hermetically-sealed
General purpose
Explosion-proof

- Backlighted Name Plates
- Turret Lenses
- Bull's eye

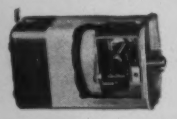


Heavy-Duty
SAFE-LOCK RECEPTACLES

For hazardous and explosive areas . . . and all general purpose applications.

Heavy-Duty
MERCURY SAFETY SWITCHES

For hazardous and corrosive atmospheres and all general purpose applications.



MOTOR
DRIVEN
FLASHERS

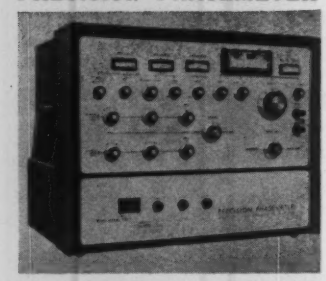
with mercury switch interrupters

Write for Descriptive Bulletins

Tigerman Engineering
COMPANY
4332 North Western Avenue
Chicago 18, Illinois

CIRCLE 130 ON READER-SERVICE CARD

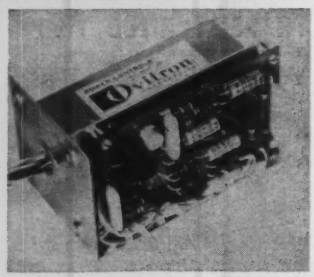
PRECISION PHASEMETER



New Precision Phasemeter, Model 1010, features 0.1° absolute accuracy over the entire 0-360° phase range without ambiguity, and direct reading of phase difference over frequency range from 30 to 20,000 cps. —*Maxson Electronics Corp.*, 475-10*th Ave., New York* 18, *N. Y.*

CIRCLE 289 ON READER-SERVICE CARD

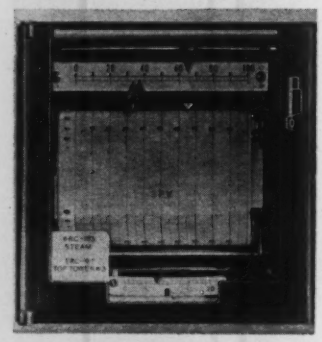
MAGNETIC PREAMPLIFIER



New magnetic Phase-control Amplifier and all-silicon Transistor Preamplifier, for triggering thyratrons or controlled rectifiers and other switching elements used in phase-controlled a-c power amplifiers and power control systems, is fail safe. With preamplifier, the typical signal for full thyratron power output is less than 5 mv ac into 1000 ohms.— *Ovitron Corp., Power Controls Div.*, 105 *River Rd., Cos Cob, Conn.*

CIRCLE 290 ON READER-SERVICE CARD

PNEUMATIC RECEIVERS



New line of 4"-chart Metagraphic Pneumatic Receivers, features rectilinear coordinates, chart mounted on a chart-drive that is removable from the instrument chassis, capillary inking systems, brightly colored pointers, simplified switching functions.—*Bristol Co., Waterbury* 20, *Conn.*

CIRCLE 291 ON READER-SERVICE CARD

DIMENSIONAL GAGE

New line of E-Z Dial Groove Gages permits accurate readings of internal groove dimensions without use of micrometer. Range 0.2" to 1.6" dia with depths 0.080" to 0.350". Accurate to fractions of 0.0005".—*Maxwell Industries, Inc.*, 493 *E.* 5th *St., Ashtabula, Ohio.*

CIRCLE 238 ON READER-SERVICE CARD

PLASTIC THERMOCOUPLE

New Model "P" Thermocouple thermal elements are flat-ribbon wires, insulated by thin sheets of mica. Components are sandwiched between split tapered pin and pressed into thermocouple housing. All material in sensing tip (except wires and insulation) is made of same material as wall of test vehicle under study, which eliminates error due to differences in thermal properties at point of measurement. Response time is less than 10 sec, temperature range 320° to 5000°F, operating pressures to 5,000 psig.— *Nanmac Corp., Dept.* 11, *Box* 8, *Indian Head, Md.*

CIRCLE 239 ON READER-SERVICE CARD

PRESSURE REGULATOR

New extra-sensitive Pressure Regulator of ductile iron (#160A) or bronze (#260A) has control range 0.5 to 125 psi, max pressure drop 175 psi, min 3 psi. Severe test on steam service with 20 psig inlet and 7 psig outlet showed swing of only ±0.1.— Bulletin PNB 5-61.—*OPW-Jordan*, 6013 *Wiehe Rd., Cincinnati* 37, *Ohio.*

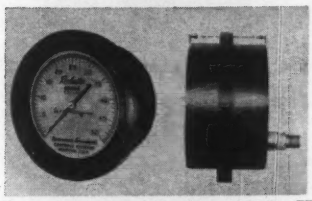
CIRCLE 240 ON READER-SERVICE CARD

DIGITAL MULTIPLE METER

New digital multimeter (DMM) combines Voldicon V16-AD basic voltage-to-digital converter with multipurpose signal conditioner and programming accessory modules. Includes provisions for self-synchronous rms a-c measurements in absolute mode, and for completely independent phase and amplitude reference inputs in a-c ratio modes. Utilizes all semiconductor circuitry.—*Adage, Inc.*, 292 *Main St., Cambridge* 42, *Mass.*

CIRCLE 241 ON READER-SERVICE CARD

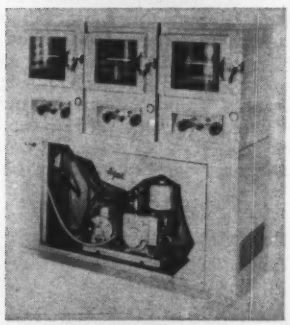
HIGH-PRESS GAGE



New gearless Series 6925 High Pressure Gage for pneumatic or hydraulic service up to 10,000 psig withstands excessive cycling and features accuracy of ±¼% full scale. Hysteresis, friction, and backlash are below readable limits. Contains helical-wound Inconel X bourdon tube. Available in 4½" and 6" dial sizes.—*American-Standard, Controls Div.*, 5900 *Trumbull Ave., Detroit* 8, *Mich.*

CIRCLE 242 ON READER-SERVICE CARD

OVEN ASSEMBLY



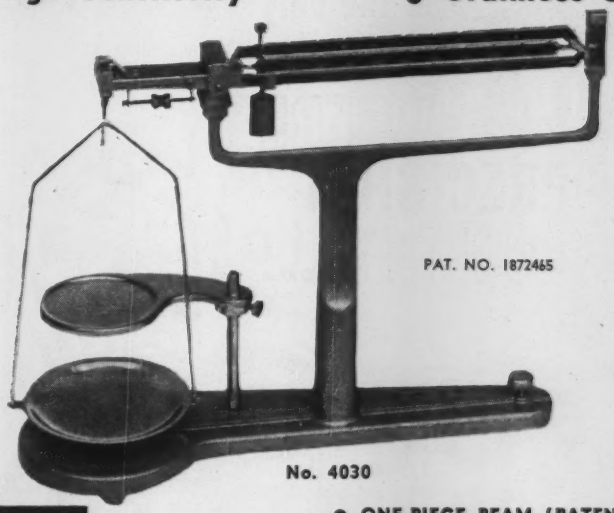
New Model 8435 three-vacuum Oven Assembly mounted on one cabinet facilitates production vacuum bake-out of semi-conductor devices and other components at 200° or 300°C. Single standard roughing pump evacuates to 1 x 10^{-4} mm Hg. Electric solenoids evacuate ovens to be evacuated collectively or individually. Stainless steel work chambers 18" x 18" x 18".—*Electric Hotpack Co., Inc.; Cottman Ave. at Melrose St., Philadelphia* 35, *Pa.*

CIRCLE 243 ON READER-SERVICE CARD

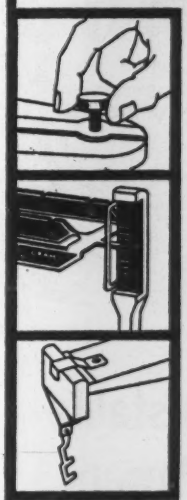
Welch **High Form**

TRIPLE BEAM BALANCE

• **High Sensitivity** • **Stainless Steel**



No. 4030



JUST ONE LEVELING SCREW TO ADJUST

You turn only one easily accessible leveling screw to place balance in instant adjustment.

BEAM POSITION INDICATED BY GRADUATED END SCALE

You see at a glance the approximate adjustment of the centigram rider you need to complete the weighing.

STIRRUP CAN'T FALL OFF

The Cobalite stirrup knife edge and its agate bearing have a protective cover with a retainer to prevent accidental stirrup removal.

- **ONE-PIECE BEAM (PATENTED)**
- **ELECTROPOLISHED SURFACES**
- **REVERSE ETCHED SCALES**
- **POSITIVE-SETTING SLIDING WEIGHT**

Capacity: 111 grams
Sensitive to 0.01 gram
Includes adjustable platform for gravity determinations
Over-all dimensions 14 x 4¼ x 11 inches high
Net weight 2 lbs.
Shipping weight 3½ lbs.

4030. **TRIPLE BEAM BALANCE, High Form.** Each, $27.50

4031. **AUXILIARY WEIGHT. For increasing the capacity of No. 4030 Balance to 201 grams.** Each, $1.50

4030C. **PLASTIC COVER, For No. 4030.** Each, $1.60

THE WELCH SCIENTIFIC COMPANY
ESTABLISHED 1880
1515 Sedgwick Street, Dept. B Chicago 10, Illinois, U.S.A.
Manufacturers of Scientific Instruments and Laboratory Apparatus

CIRCLE 94 ON READER-SERVICE CARD

TAPE RECORDER/REPRODUCER

New two-channel, two-speed compact magnetic tape Recorder/Reproducer Model R169-C, primarily for mobile use, can be obtained in variations as to tape width, number of channels, tape speeds, etc. Accepts up to 10½" reels with standard NAB hub. Separate record and playback amplifiers for each channel are fully transistorized.—*American Concertone, Inc.*, 9449 *W. Jefferson Blvd., Culver City, Calif.*

CIRCLE 244 ON READER-SERVICE CARD

ELECTROHYDRAULIC ACTUATOR

New 20,000 Series Model EHA-1 Electrohydraulic Actuator offers speed, high frequency response, positional accuracy and large thrust. Major components are transistorized amplifier with plug-in circuits, conductive plastic infinite resolution type feedback potentiometer, hydraulic servovalve, and heavy duty power cylinder. Servovalve and cylinder are sized to provide thrust and frequency response to fit requirements.—*Annin Co.*, 1040 *S. Vail Ave., Montebello, Calif.*

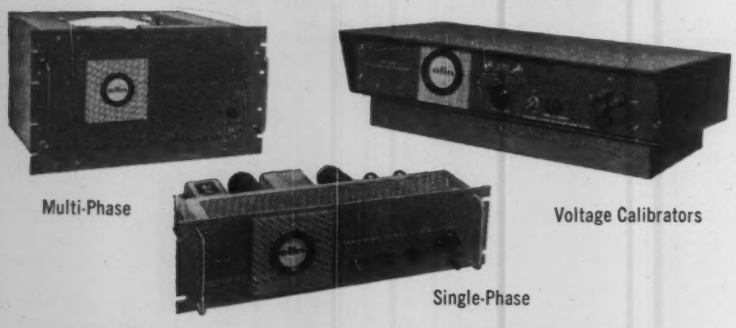
CIRCLE 245 ON READER-SERVICE CARD

ēlin
instrumentation is the only answer

WHERE PRECISION COUNTS...!

You can depend on ELIN to meet your precision AC power requirements on gyros, bridge-type transducers, synchros, servo systems, resolvers and many other AC devices.
Ask about the new load-regulated amplifiers for production line testing. External sync. provides master-remote features without sacrifice in over-all stability.
Complete power systems available for your specific needs.

Ultra-stable AC Power Sources



Multi-Phase

Voltage Calibrators

Single-Phase

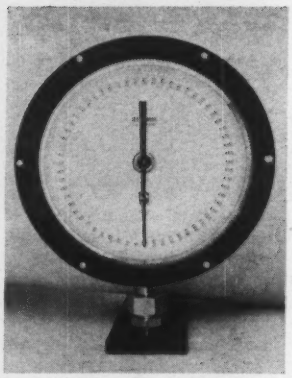
Write for NEW 1960 Catalog

ēlin DIVISION

INTERNATIONAL ELECTRONIC RESEARCH CORPORATION
135 West Magnolia Boulevard, Burbank, California • Victoria 9-2481

CIRCLE 95 ON READER-SERVICE CARD

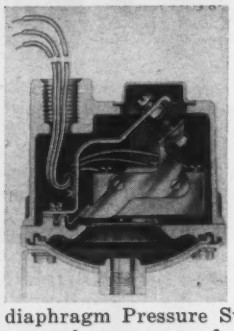
TEST GAGE



New Precision Pressure Gage with 8½", 360° calibrated dial has scale length equal to 12", 270° calibrated dial. Employs bourdon tube made of Ni-Span C with inherent temperature stability. Used as substitute for dead weight testers for calibration work. Bulletin M-45.—*Martin Decker Corp.*, 3431 *Cherry Ave., Long Beach* 7, *Calif.*

CIRCLE 246 ON READER-SERVICE CARD

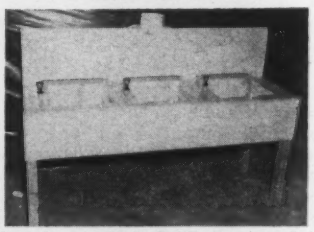
PRESSURE SWITCHES



New diaphragm Pressure Switches have improved accuracy of ±0.5% with ±0.2% available on request. Erector set technique (standard body with interchangeable contact elements, capsules, terminal block housings, etc.), allows wide choice, low cost. Proof pressures are to 300 psig and adjustable ranges from vacuum to 150 psig.—*Barksdale Valves*, 5125 *Alcoa Ave., Los Angeles* 58, *Calif.*

CIRCLE 247 ON READER-SERVICE CARD

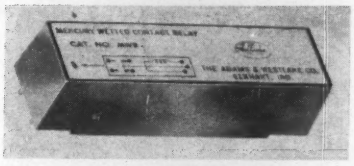
LAB UNIT



New low-cost Lab Unit, completely constructed of polyethylene parts from stock, containing sinks, bench tops, and fume hoods, is unaffected by strong acids. Recommended for work in transistor and semiconductor field. —*Bel-Art Products, Pequannock, N. J.*

CIRCLE 248 ON READER-SERVICE CARD

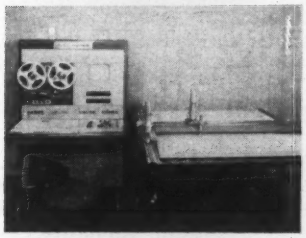
MERCURY-WETTED CONTACT RELAYS



New epoxy-molded Type MWB-1600 mercury-wetted single-contact Relay (illustrated), ⅞" x ⅞" by 3", and two-contact type MWB-2600 (⅞" x 1.23" x 3") feature high component density ideal for computer and peripheral equipment applications, low contact resistance, operating speeds of up to 100 operations/sec. Handle loads up to 250 va, 500 v, 5 amp max. —*Adams and Westlake Co., Elkhart, Ind.*

CIRCLE 249 ON READER-SERVICE CARD

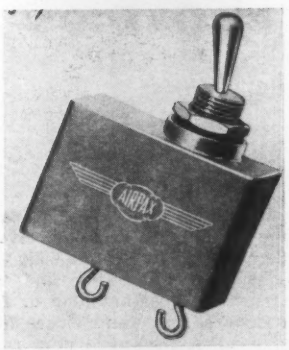
AUTOMATED PLOTTER



New Aero-Digitork Coordinatograph system provides power-positioning of X and Y carriages through series of digitork stepping motors with manual control by punched paper tape, cards, or multi-channel magnetic tape, resulting in automatically programmed point-to-point or continuous line plotting over 47¼" x 47¼" surface to ±0.0015".—*Aero Service Corp., 210 E. Courtland St., Phila. 20, Pa.*

CIRCLE 250 ON READER-SERVICE CARD

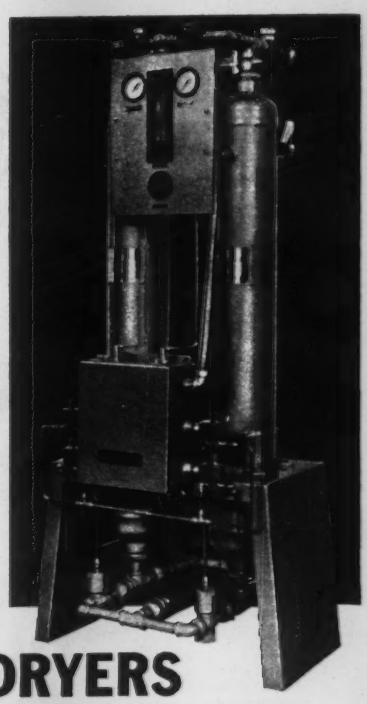
CIRCUIT BREAKER



New electromagnetic Circuit Breaker with slow, fast, or instantaneous delay provides trip-free action which makes it impossible to maintain contacts closed when it is carrying current that would normally trip breaker. Available in d-c and a-c ratings from 0.05 to 15 amp.—*Airpax Electronics Inc., Cambridge Div., Cambridge, Md.*

CIRCLE 251 ON READER-SERVICE CARD

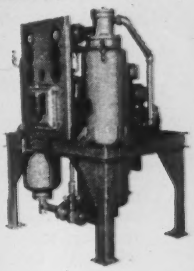
Reliable Dry Air for Control of INSTRUMENTATION with TRINITY *Heat-Les* DRYERS



Here is the most economical—both initially and maintenance-wise—source of dry air for instrumentation. The Trinity Heat-Les dryer has no heaters—operates on a principle so simple, so efficient that operating costs are cut to a minimum while performance exceeds that of any other dryer design. Proved in hundreds of installations.

ALSO HEAT-REACTIVATED DRYERS

Trinity also offers a complete range of capacities in heat-reactivated type dryers of an advanced design, offering the greatest economies and performance for this type dryer... **WRITE FOR COMPLETE TRINITY DRYER AND ACCESSORY TECHNICAL MANUALS...**



TRINITY World leader in dry gas/air systems

TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

Visit Us At The ISA Conference,
"Hawaiian Aloha Party" Sept. 12-13-14
Room 3339 Biltmore Hotel, Los Angeles 5 PM—Till ? ?

CIRCLE 93 ON READER-SERVICE CARD

Over 40,000 copies of the 1962 ICS' BUYERS GUIDE

will be distributed to instrument and control equipment and component users. Publication date—October 1961. Be sure your products are represented with complete data in Catalog Ads and free listings. Contact any of our reps, listed on page 1336—or write ICS' Buyers Guide 845 Ridge Ave., Pittsburgh 12, Pa.

DETECTOTEMP PAINT
used on the X-15
YIELDS VITAL TEMPERATURE DATA

Major Robert White, shown standing next to DetectoTemp painted nose cone.

Color Changing Paint Indicates Surface Temperatures and Thermal Distribution

Prior to the historic X-15 flight, DetectoTemp paint was applied on the metal nose surface of the craft to record 'in-flight' skin temperatures. As the X-15 rocketed to 2905 mph, this unique paint progressively changed from its original green color to blue, yellow, black and finally brown as the surface temperature increased due to air friction.

This dramatic application emphasized the outstanding characteristics which have proved DetectoTemp ideal for all applications ranging from micro-miniature circuitry to large surface areas. Easy-to-see color changes represent definite temperature points and give DetectoTemp the unique ability to indicate local temperature variations.

For further information on how this amazing product can benefit your program, phone Swinburne 9-0500 or write.

DETECTOTEMP
Available in 4 oz. and 1 lb. metal cans. 36 types cover temperatures from 40° C to 1350°C. Multichange paints available with as many as 4 color changes.

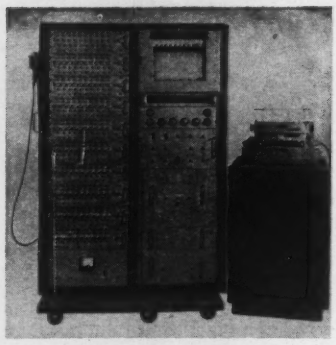
Also available
Thermochrom
Color changing crayons ideal for on-the-spot temperature checks. 18 crayons cover temperatures from 65°C to 670°C.

CURTISS WRIGHT CORPORATION
Princeton Division • Princeton, New Jersey
IN CANADA: Canadian Curtiss-Wright Ltd., Industrial Process Controls, Davis Road, Oakville, Ontario

Also available through your AIRCO distributor

CIRCLE 97 ON READER-SERVICE CARD

STRAIN GAGE PLOTTER



New multi-channel Strain Gage Recording and Plotting System with digital and analog outputs utilizes 10 input conditioning modules of 10 channels each. Decimal lamp bank offers a continuous visual indication of varying data. Permanent analog record is produced by recorder. The flexowriter's output is both a typewritten log sheet and punched paper tape for computer entry. Bulletin 410.—*B & F Instruments, Inc.*, 3644 *N. Lawrence St., Phila.* 40, *Pa.*

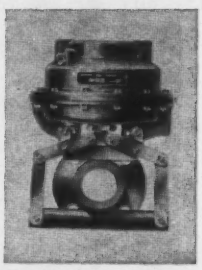
CIRCLE 252 ON READER-SERVICE CARD

2-WAY SOLENOID VALVE

New 8261 packless, direct acting, normally closed, miniature 2-way solenoid Valve has 2 operating parts, is 2-17/32" high, has 1/4" pipe connections and 3/32" orifice. Valve mounts in any position; moving parts are accessible with valve in line.—*Automatic Switch Co., Florham Park, N. J.*

CIRCLE 253 ON READER-SERVICE CARD

FLEX HOSE CONTROL VALVE



New ful-flo Flex Valve for control of abrasive slurries and corrosive materials has simple pipe-like body which provides full capacity and unobstructed flow. Does not plug or freeze in outdoor service, and closes bubble tight. Available in pure gum rubber, Buna-S, Buna-N, Neoprene, and butyl, or compounds of each, in sizes 1" to 12".—*Farris Flexible Valve Corp., Palisades Park, N. J.*

CIRCLE 254 ON READER-SERVICE CARD

End of ISA Show Product Previews

NEW INSTRUMENTS

DATA RECORDING

New Data Chamber accessory for Beattie Oscillotron permits written record on corner of oscilloscope recording film. Permanently-focused optical system is independent of camera lens and shutter.—*Beattie-Coleman, Inc.*, 1010 *N. Olive St., Anaheim, Calif.*

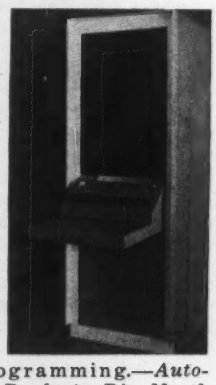
CIRCLE 255 ON READER-SERVICE CARD

TIME TOTALIZER

New Time Totalizer indicates accumulated hours of operation, is mercury coulometer operated by integral electrical network which compensates for temperature differences and supply voltage variations. Two models for a-c or d-c feature resistance to error from vibration, shock; wide temperature ranges.—*Leland Airborne Products Div., American Machine & Foundry Co.*, 261 *Madison Ave., New York* 16, *N. Y.*

CIRCLE 256 ON READER-SERVICE CARD

CIRCUIT ANALYZER



New Nifte Circuit Analyzer analyzes from 500 to 18,000 circuit points, checks wire continuity by comparing two units. Flashing panel light identifies error, connector and pin location. Eliminates need for tape or card programming, matrix chart or plug-board programming.—*Autonetics-Industrial Products, Div. North American Aviation, Inc.*, 3400 *E.* 70 *St., North Long Beach, Calif.*

CIRCLE 257 ON READER-SERVICE CARD

NEW BARTON 273 PNEUMATIC TRANSMITTER MEETS MORE APPLICATION REQUIREMENTS THAN ANY OTHER TRANSMITTER

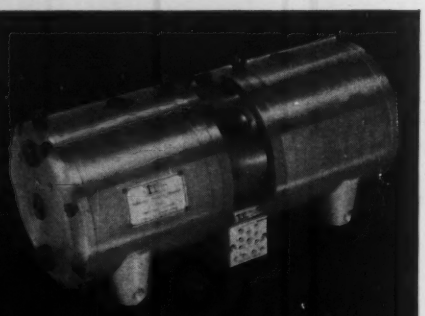
The Barton 273 offers the widest differential pressure ranges (0-8" w.c. to 0-400 psi), the highest safe working pressures (to 10,000 psi), and the widest variety of housing materials (aluminum, brass, steel, 316 stainless steel). It's compact, weighing up to less than ½ the weight of other units. It has adjustable suppression up to 80% of DP range, and adjustable span. A non-bleed relay minimizes air consumption. It doesn't shift zero on overrange. It's unaffected by normal piping stress. In every respect, the Barton 273 is the most significant advance in pneumatic transmitters in the past decade. There's a lot more you should know about it—for complete data write

BARTON

INSTRUMENT CORPORATION, 580 MONTEREY PASS ROAD, MONTEREY PARK, CALIFORNIA.

CIRCLE 98 ON READER-SERVICE CARD

dynamic new concept of vibration testing produces



NEW PRIME ACCELEROMETER CALIBRATOR

Here's further proof of the advantages of ITT's dramatic new approach in air-suspended, lateral motion accelerometer calibrators: the ST-200 vibration exciter. Developed at the request of a major Government facility for their *prime* standard, the ST-200 will provide *double the accuracy* of other known standards.

The unique concepts of air-suspension and lateral motion that provide the performance features of the new ST-200 are also an integral part of other ITT vibration exciters for secondary and routine accelerometer calibration. These same techniques are easily adapted to other special vibration and shock testing requirements.

For complete information, applications data and performance curves, contact your ITT representative or write for Data File ICS-1469-3.

Other ITT vibration exciters for accelerometer calibration may be integrated into your present system design or can be ordered as part of complete, self-contained ITT testing systems.

ST-110 for secondary standards

ST-115 for routine calibration

ITT

Industrial Products Division

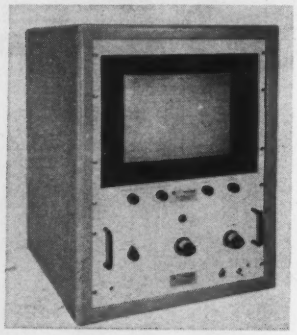
International Telephone and Telegraph Corporation

15191 Bledsoe Street • San Fernando, Calif. • EMpire 7-6161

power conversion • instruments • closed circuit TV • avionics • mobile radio/telephone

CIRCLE 202 ON READER-SERVICE CARD

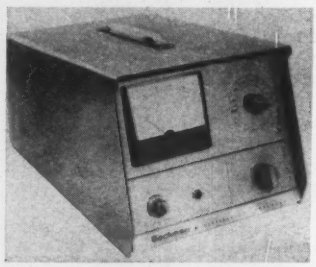
BAR GRAPH OSCILLOSCOPE



New Bar Graph Oscilloscope, ATL Profile Monitor Model 220, displays temp, pressure, strain, etc. from 48 inputs measurable by electrical output. Features selective vertical gain sensitivity, zero suppression control, automatic alarm system, electronic calibration grid line.—*Advanced Technology Labs., Dept. M-1, 369 Whisman Rd., Mountain View, Calif.*

CIRCLE 258 ON READER-SERVICE CARD

HYDROCARBON ANALYZERS

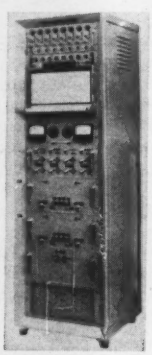


Two new Total Hydrocarbon Analyzers detect and measure trace concentrations of hydrocarbons in gases, vapors, or atmosphere. Model 108 for panel mounting, Model 109 (illustrated) for laboratory or field use operate on principle of hydrogen flame ionization of carbon atoms. Bulletin. —*Scientific and Process Instruments Div., Beckman Instruments, Inc., Fullerton, Calif.*

CIRCLE 259 ON READER-SERVICE CARD

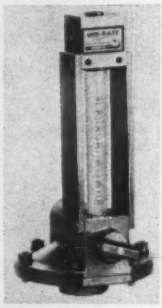
A-C POWER SOURCE

New a-c Power Source Model GE-S-7-100 supplies power for four 2-phase gyro motors. Eight-channel recorder simultaneously charts phase voltage (sensitivity to 0.01%/cm) and in-phase component of current consumed by that phase (sensitivity to 0.5 ma/cm).—*Behlman Engineering, Burbank, Calif.*



CIRCLE 260 ON READER-SERVICE CARD

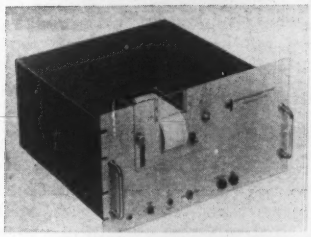
ROTAMETER/CONTROLLER



New self-contained, Series 8800 flow-rate Controller includes rotameter mounted on needle-valve-operated flow controller. Internal diaphragm assembly gives constant pressure differential for any valve setting. Flow capacities: 0.01^{-12} gph (water) or 0.2^{-48}scfh (air). Bulletin 148. —*Brooks Instrument Co., Inc., Hatfield, Pa.*

CIRCLE 261 ON READER-SERVICE CARD

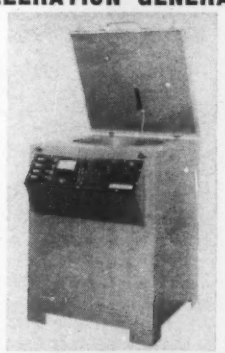
DIGITAL PRINTER



New Model 400DT Digital Printer has front tape feed, couples to any electronic counting equipment or control system that provides 1-2-4-8 output with a voltage swing of −6 v. Operates directly with CMC solid-state digital instrumentation.—*Computer Measurements Co., Sylmar, Calif.*

CIRCLE 262 ON READER-SERVICE CARD

ACCELERATION GENERATOR



New Rotary Acceleration Generator Model RA-ATC-500-1 tests dynamic characteristics of instruments from 3 G to 500 G pounds. Employs dual controls to provide infinite variable platform speed within operating range 10 to 2000 rpm. 20 silver slip rings are completely shielded. Slip ring noise (2 brushes per ring) is 1 μv max at 1 ma. System accuracy is 0.5% over full range with line voltage regulator. For speeds above 40 rpm, wow is 0.5% and drift is 0.1%. Vibrational resolution is 0.02 G's.—*Pacific Southwest Instrument Labs., 5705 Centinella, Culver City, Calif.*

CIRCLE 263 ON READER-SERVICE CARD

FOR LARGE COMPONENTS AND SMALL SUBSYSTEMS . . . the new ITT ST-300 offers a 250 force-pound exciter for vibration *and* shock testing. This latest in a series of dynamic new vibration equipment utilizes the unique concepts of lateral motion excitation and air-bearing support—both developed by ITT engineering and proved on ITT's other vibration exciters of the 100 and 200 Series.

The exceptionally flat frequency response of the ST-300 permits precise testing without the need for elaborate compensating devices. Natural resonances are unaffected by table loadings. In addition, by checking shock *and* vibration on the same instrument, testing time and cost are substantially reduced. Other significant features of the ST-300 include:

- *no significant distortion throughout normal test range*
- *first major resonance above 5 Kc*
- *useful frequency from 5 cycles to 50 Kc*
- *shock testing to over 5,000 g's*
- *table size: 5" x 8"*

For complete information and applications data, call an ITT Instruments representative or write for Data File ICS-1426-1

Other ITT vibration exciters include:

ST-150 for testing one ounce loads to over 100 g's

ST-100 for small component production testing and accelerometer calibration

ITT

Industrial Products Division

International Telephone and Telegraph Corporation
15191 Bledsoe Street • San Fernando, Calif. • EMpire 7-6161

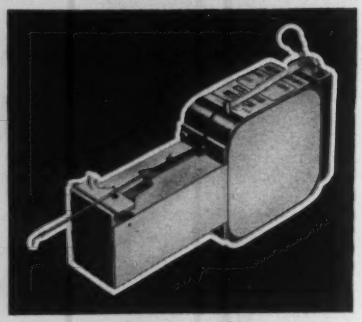
power conversion • instruments • closed circuit TV • avionics • mobile radio/telephone

CIRCLE 100 ON READER-SERVICE CARD

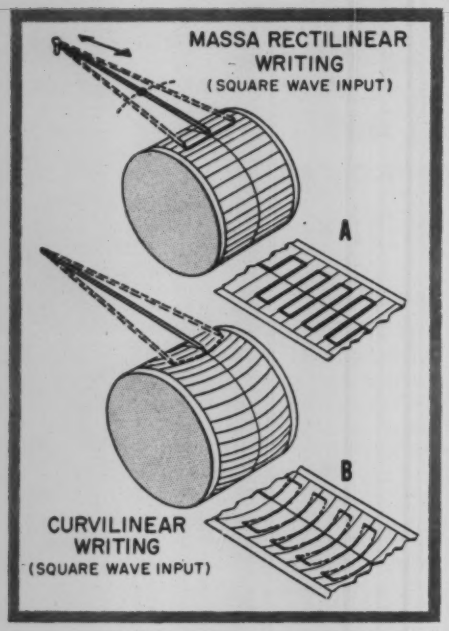
MASSA RECTILINEAR PEN MOTORS

NOW PERMIT

UNDISTORTED OSCILLOGRAPH RECORDINGS ON CYLINDRICAL SURFACES



Massa Rectilinear Pen Motors write equally well on either flat or cylindrical surfaces. Regardless of the drum's radius, the pen is in continuous contact with the paper. The resulting oscillograms are therefore clear and correctly written. The waveforms produced are identical to the actual input signals for easier readout and extraction of data. Massa pen motors are capable of inexpensive ink writing, and are easily converted to electrical writing.



Because the Massa Rectilinear pen motor stylus writes in a straight line, its pen tip remains in contact with the drum over the total excursion. The result is a perfect oscillogram (A), ideal for accurate timing applications.

On the other hand, since the curvilinear device cannot produce a straight line, the pen tip does not remain in correct contact with the drum over the total excursion. The resulting oscillogram waveforms (B) are distorted and unsuitable for accurate timing.

The versatile Massa Rectilinear Pen Motor is a direct replacement for curvilinear pen motors now in use. They are ideal for specialized recorder designs developed by Original Equipment Manufacturers, for geophysical and electromedical applications.

The Massa Pen Motor is small in size 4 5/8" L x 1 1/4" W x 3 1/4"H; light in weight, only 1 1/2 lbs. Maximum undistorted amplitude: Full scale, 40 mm. Frequency Response: DC to 120 cps.

Write for Oscillograph Bulletin, OS-600C.

Massa Division also manufactures complete rack-mounted and portable multichannel recording systems, related preamplifiers and power amplifiers.

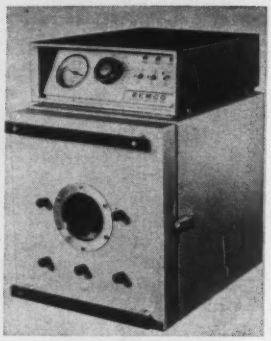
AT WESCON — BOOTH #2019-2021

OTHER MASSA PRODUCTS
TRANSDUCERS
Sonar, Ultrasonic
ACCELEROMETERS
MICROPHONES
HYDROPHONES
AMPLIFIERS

MASSA
A DIVISION OF
COHU
ELECTRONICS, INC.
276 LINCOLN STREET
HINGHAM, MASSACHUSETTS,

CIRCLE 101 ON READER-SERVICE CARD

TEMPERATURE CHAMBER



New high-low Temperature Chamber for −100° to +600°F has resistance bridge control, uses liquid CO_2 refrigerant. Temperature lowers from +70° to −100° within 5 min, increases from +70° to +600°F in 45 min.—*Bemco Inc.*, 11631 *Vanowen St., North Hollywood, Calif.*

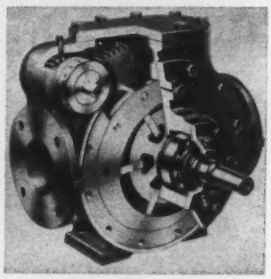
CIRCLE 264 ON READER-SERVICE CARD

COMPUTER ACCESSORY

New DC-11 Data Communicator accessory to G-20 Computer increases computer's net input/output speed, with simultaneous computing operations, to 480,000 characters/sec. Each of unit's four channels relays data between G-20's central processor and input/output devices.—*Computer Div., Bendix Corp.*, 5630 *Arbor Vitae St., Los Angeles* 45, *Calif.*

CIRCLE 265 ON READER-SERVICE CARD

VARIABLE-FLOW PUMPS



New Vari-Flow rotary pumps enable instant "dialing" of any desired flow rate from zero to full capacity, also reverse flow without changing pump speed. Bulletin 600.—*Blackmer Pump Co., Grand Rapids, Mich.*

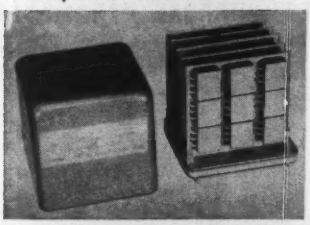
CIRCLE 266 ON READER-SERVICE CARD

STRAIN-GAGE TRANSDUCER

New silicon-semiconductor strain-gage Pressure Transducer gives 250-mv output without amplifier with 10 to 30 v dc excitation in airborne and ruggedized models, is responsive to static and high-frequency dynamic pressures. Pressure range, 0-100 through 0-10,000 psig or psia; linearity, 0.25% max through zero and 100% pressure points.—*Fairchild Controls Corp.*, 219 *Park Ave., Hicksville, L.I., N. Y.*

CIRCLE 267 ON READER-SERVICE CARD

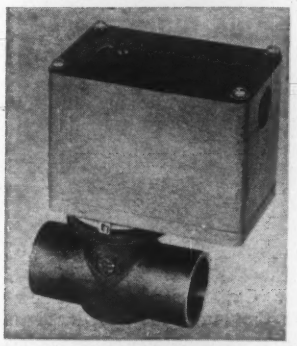
AN/DIG CONVERTER



New solid-state Analog-digital Converter, Model ADC-1, has better than 0.5% accuracy, 1,000 readings/sec, 8 binary bits. Input is one v and up, 10,000 ohms/v; output is either serial or parallel. Catalog 2.—*Dynamic System Electronics*, 2001 *N. Scottsdale Rd., Scottsdale, Ariz.*

CIRCLE 268 ON READER-SERVICE CARD

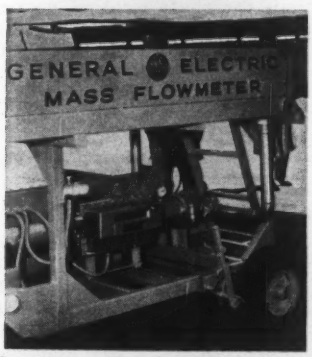
HYDRONIC ZONE VALVE



New thermostatically-controlled, motor-operated Hydronic Zone Valve, Model VM-120, controls water or steam in residential and light commercial heating or cooling systems, is low-voltage wing type for installation at radiator or in supply piping to zone to be controlled.—*General Controls Co.*, 801 *Allen Ave., Glendale* 1, *Calif.*

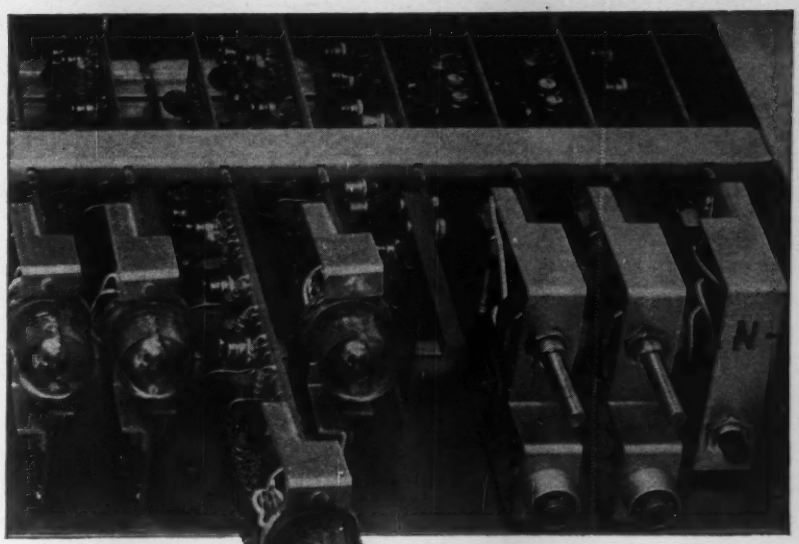
CIRCLE 269 ON READER-SERVICE CARD

MASS FLOWMETER



New high-accuracy, explosion-proof Mass Flowmeter System for ground refueling of jet aircraft is cart-mounted, measures to 320,000 lb/hr flow rates. System includes Type LB-2 integrating mass flowmeter, battery-operated power supply, and pulse-operated ticket printer.—*General Electric Co., Schenectady* 5, *N. Y.*

CIRCLE 270 ON READER-SERVICE CARD



THIS IS WHERE IT COUNTS

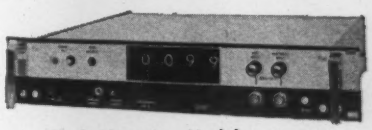
NEW ERIE SOLID STATE 500T BI-DIRECTIONAL CONTROL COUNTER

This is a rugged high-speed control counter with bi-directional capabilities for digital closed loop control. It offers for the first time anti-coincidence circuits for random add/subtract inputs, a digital-to-analog converter and an excess error alarm. The instrument has true modular construction in which individual circuit boards are readily inserted from the front for functional versatility and ease of maintenance. In-line NIXIE readout can be supplied when required.

The unique anti-coincidence circuit used prevents interference between add and subtract pulses arriving simultaneously. This provides absolute accuracy as opposed to conventional anti-coincidence circuits. The analog output is proportional in both magnitude and polarity to the algebraic sum of the add and subtract inputs. The readout indicates the instantaneous algebraic sum.

For example, where the 500T is used for control of motor speeds, the pulses arrive at both the add and subtract inputs at exactly the same rate when the controlled motor is running at the desired speed. Any speed change develops an analog output to a servo system which returns the motor to the proper speed. The same basic process would apply to the mixing of liquids or chemicals.

Applications for the 500T are virtually unlimited since it provides digital control of such parameters as flow, speed, position, and many others. An industrial case is available for applications in rugged environments.



Rack Mounting Model

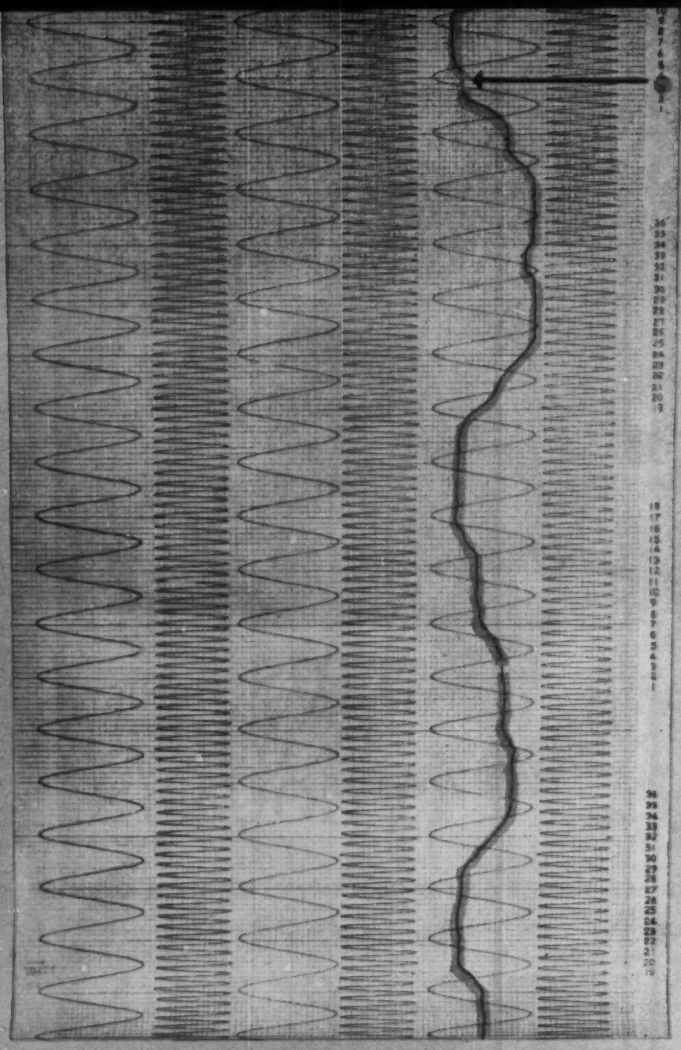
Industrial Model

Complete technical information available on request.

Quality Where It Counts
ERIE Instrumation.

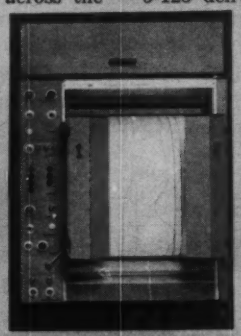
ERIE PACIFIC, DIVISION OF
ERIE RESISTOR CORPORATION
12932 S. Weber Way, Hawthorne, California

CIRCLE 102 ON READER-SERVICE CARD



UP TO 52 CHANNELS OF IMMEDIATE DATA... ALL WITH INSTANT, POSITIVE TRACE IDENTIFICATION

See for yourself how easy it is to identify traces on print-out records produced by CEC's 5-123 Recording Oscillograph. To find the channel number of any trace, simply lay a straight edge across the trace at the point of the identification interruption. The straight edge will intersect one of the trace numbers automatically printed along the right side of the oscillogram. This immediate trace identification means faster data reduction. The 5-123 is available in 36 & 52-channel models.



Rapid, positive trace identification is but one of the many features of the 5-123. When equipped with CEC's exclusive optional "DATAFLASH"*, the 5-123 delivers ready-to-read traces 60 times faster than any other print-out process available. Push-button controls let you change recording speeds instantly—from 0.1 to 160 inches per second.

For complete information, call your nearest CEC sales and service office or write for Bulletin CEC 1623-X22.

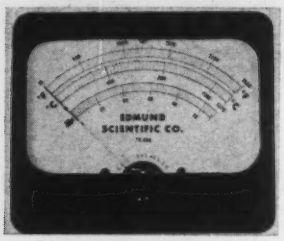
**Patent Pending*

Data Recorders Division **CEC**

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF Bell & Howell · FINER PRODUCTS THROUGH IMAGINATION

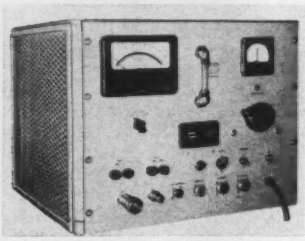
MULTI-PURPOSE PYROMETER



New Pyrometer can be used with base-metal thermocouples or as millivoltmeter. Features three scales, one for direct use with type K thermocouples. Conversion tables for type J, type L and type T thermocouples, and F to C.—*Edmund Scientific Co., Barrington* 50, *N. J.*

CIRCLE 271 ON READER-SERVICE CARD

CALORIMETER



New Calorimeter measures any power that can be transferred to circulating fluid; consists of constant-flow circulating system, cooling system, thermopile and microammeter. Direct reading, can be calibrated in watts, BTU/min, hp, or ft-lb/min. In ranges from 0.1 to 3000 BTU/min. —*Electro Impulse Laboratory, Inc.,* 208 *River St., Red Bank, N. J.*

CIRCLE 272 ON READER-SERVICE CARD

SHAFT POSITION ENCODER

New Datex Model C-701 Shaft Position Encoder provides up to 1024 positions per shaft rotation, features high resolution and accuracy. A sealed unit, it operates in range of −65° to +162°F, conforms to MIL specs for humidity, salt spray, and vibration. Bulletin.—*Datex Corp.,* 1307 *S. Myrtle Ave., Monrovia, Calif.*

CIRCLE 497 ON READER-SERVICE CARD

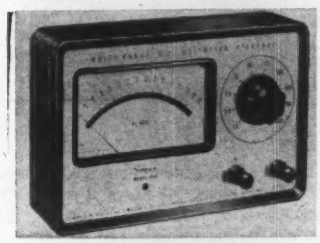
ANNUNCIATOR READOUT

New Series 90-H Display for annunciators displays 60 messages individually or in any combination. Dimensions: 5½" x 12" x 16½".—*Industrial Electronic Engineers, Inc.,* 5528 *Vineland Ave., North Hollywood, Calif.*

CIRCLE 273 ON READER-SERVICE CARD

←**CIRCLE 103 ON READER-SERVICE CARD**

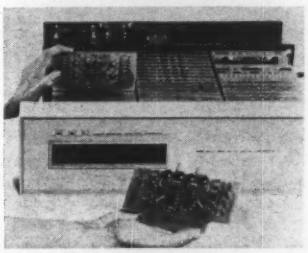
LABORATORY STANDARDS



New Model 1700 DC Voltmeter and Model 1702 DC Milliammeter feature self-shielding, deep core construction with spring-mounted sapphire jewels and hardened steel pivots. Temperature compensated from 15° to 35°C. Specification Sheet ST321.—*Simpson Electric Co.*, 5200 *W. Kinzie St., Chicago* 44, *Ill.*

CIRCLE 274 ON READER-SERVICE CARD

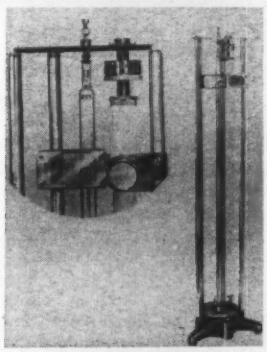
HIGH-SPEED CODER



New solid-state analog-to-digital Converter, Model ADC-1B, uses standard voltages, circuits, and logic throughout; features full 15-bit resolutions, BCD or binary (both serial and parallel) output formats, Nixie display of digital output in decimal form, etc.—*Systems Engineering Labs., Inc.* (*SEL*), 4066 *N.E. 5th Ave., Fort Lauderdale, Fla.*

CIRCLE 275 ON READER-SERVICE CARD

PRIMARY PRESSURE STANDARD



New improved FA-187 Manometer is a primary pressure standard with range of 800 mm Hg and guaranteed accuracy of 1/5000. New vernier and float increase readability to 0.01 mm Hg. Well is lined with stainless steel for protection from contamination. Fully compensated for temperature and gravity.—*Wallace & Tiernan Inc.*, 25 *Main St., Belleville* 9, *N. J.*

CIRCLE 276 ON READER-SERVICE CARD

CIRCLE 104 ON READER-SERVICE CARD →

Test big, test small... test any component fast with CEC leak detectors

CEC's two newest leak detectors provide all the answers for project or production line leak testing because they're fast... accurate... sensitive... simple to use. Look 'em over:

24-120 LEAK DETECTOR – A portable, helium/mass spectrometer type instrument that's so versatile it can locate and measure leaks in large tanks as well as small components anywhere... in plant or at the construction site. With its companion semi-automatic 24-025A Test-Port Station, the 24-120 is the fastest instrument of its type and has a sensitivity of 5×10^{-11} atm cc/sec helium. This advanced leak detector can be modified to sense argon, neon, and helium. Bulletin CEC 24120-X10.

24-510 RADIFLO LEAK DETECTOR – The foremost production-line instrument for 100% leak testing of transistors, diodes, relays, and other small sealed components. Only detector of its kind available, the semi-automatic 24-510 offers lowest unit cost for production testing and highest sensitivity, 1×10^{-11} atm cc/sec air. Bulletin CEC 24510-X5. If you are interested in submitting sample parts for Radiflo application study, call your nearest CEC sales and service office for free estimates and further details.

Analytical & Control Division **CEC**

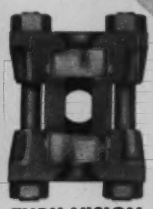
CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF **Bell & Howell** · FINER PRODUCTS THROUGH IMAGINATION

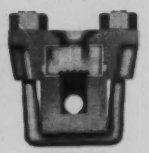
Strahman

HIGH PRESSURE GAUGES

FOR CHEMICAL PLANTS AND REFINERIES



THRU VISION



REFLEX
Single or Multiple Sections

Multiple section gauges are made with a one piece body chamber. This method of construction, originated by Strahman, has become generally adopted as standard by most gauge manufacturers.

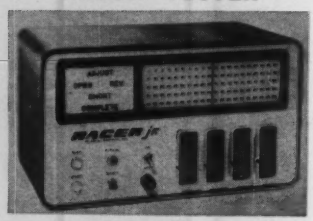
An added safety feature! Except for visibility slot, glass is completely enclosed.

- Explosion proof illuminators
- Heated or cooled gauges
- Large Chamber Gauges
- Frost-proof extensions
- Tubular Gauges
- Gauge Cocks

STRAHMAN VALVES INC.
NICOLET AVE., FLORHAM PARK, N. J.

CIRCLE 105 ON READER-SERVICE CARD

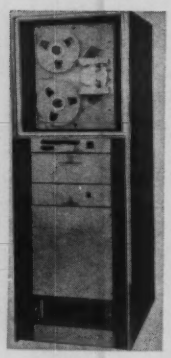
CIRCUIT TESTER



New Racer Jr., Model R1, Automatic Circuit Tester checks wiring systems, indicates on display panel. Test capacity is 100 circuits and ground (201 terminations); output (test) voltage, 24 v dc; output (test) current, 50 ma (max).—*Pearce-Simpson Electronics Div.*, 3950 *N.W.* 28 *St., Miami, Fla.*

CIRCLE 277 ON READER-SERVICE CARD

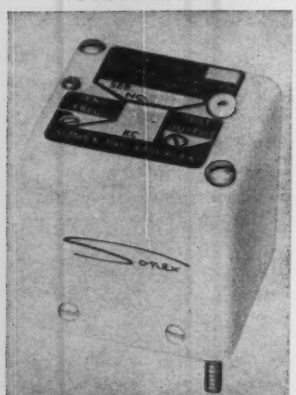
TAPE HANDLER SYSTEM



New PHD-1200 High Density System incorporates Model 906II digital magnetic tape transport, dual read/write head assembly, read/write amplifiers, deskewing buffer, manual control unit, and power supplies. New technique reads and writes tapes at packing densities of 1,200 bits/in with transient errors fewer than 1 bit in 10^9.—*Potter Instrument Co., Inc., Sunnyside Blvd., Plainview, N. Y.*

CIRCLE 278 ON READER-SERVICE CARD

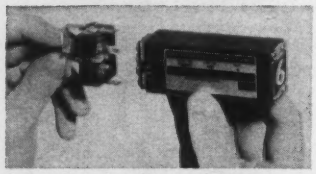
OSCILLATOR



New solid-state Voltage Controlled Oscillator, Model TEX-3000, is "first sub-carrier oscillator affording operation of telemetry systems in rapidly changing temperature environments without degradation of performance." Deviation sensitivity is 100% for 5-v or ±2.5-v input, distortion less than 1%.—*Sonex, Inc.*, 20 *E. Herman St., Phila.* 44, *Pa.*

CIRCLE 279 ON READER-SERVICE CARD

DIGITAL READOUT



New Series 120ooo Miniature Digital Readout now features a quick-disconnect unit which contains the readout's twelve terminals ready for wiring and facilitates lamp changing.—*Industrial Electronic Engineers, Inc.*, 5528 *Vineland Ave., North Hollywood, Calif.*

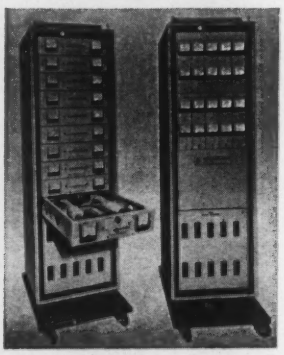
CIRCLE 494 ON READER-SERVICE CARD

CONDUCTIVITY METER

New portable Model RA-2A Conductivity Meter is completely transistorized and features direct reading in micromhos/cm and ohm/cm.—*Industrial Instruments, Inc.*, 89 *Commerce Rd., Cedar Grove, Essex Co., N. J.*

CIRCLE 495 ON READER-SERVICE CARD

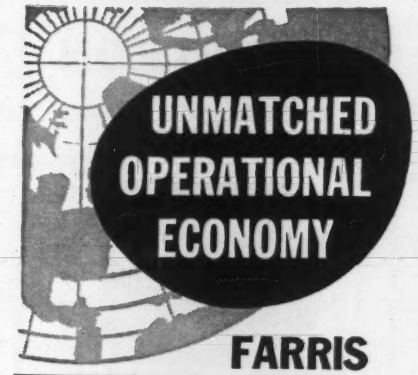
POWER REGULATORS



Two new compact a-c Power Regulator Systems for ovens, furnaces, etc., in direct proportion to control signals from set point meters, temperature controllers, programmers, etc., include Model Y4079, a single-channel, plug-in module using two C16J thyratrons for a rated capacity of 40 amp in each channel; and Model G4078 which uses ignitrons rated at 100 amp per channel.—*Research, Inc., Box* 6164, *Minneapolis* 24, *Minn.*

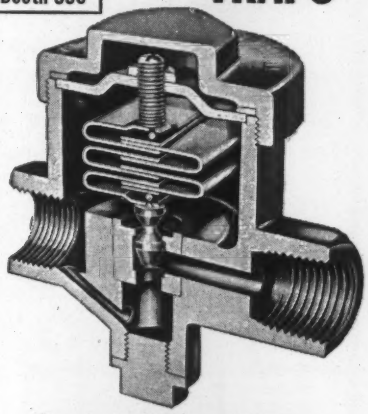
CIRCLE 496 ON READER-SERVICE CARD

USE READER-SERVICE CARD FOR QUICK SERVICE



FARRIS MIL STEAM TRAPS

See our display at the ISA Show Booth 558



Farris Mil Steam Traps have been in constant daily service for 15 years without maintenance or repair.

UNIQUE ADVANTAGES

- INDESTRUCTIBLE STAINLESS STEEL BI-METAL CONTROL ELEMENT.
- UNAFFECTED BY CORROSION, FROST, WATER HAMMER, SUPER HEAT OR ROUGH HANDLING.
- INSTANT RESPONSE TO 1°F. TEMPERATURE CHANGE
- PRESSURE BALANCED VALVES.
- STAINLESS STEEL WORKING PARTS.
- COMPACT SIZE.
- GUARANTEED 2 YEARS.

More than a Million now in service.

For Complete Information Request Catalog FE-310

Farris® ENGINEERING CORP.
MIL DIVISION
706 Commercial Avenue
Palisades Park, N. J.

CIRCLE 106 ON READER-SERVICE CARD

TAPE READER

New Typetronic Reader reads 5-8 channel punched paper tape or edge-punched cards photoelectrically, at the rate of 30 characters/sec. Capable of handling oiled or unoiled tape as well as standard colored tape.—*Smith-Corona Marchant, Inc., Data Processing Technical Sales, 410 Park Ave., New York, N. Y.*

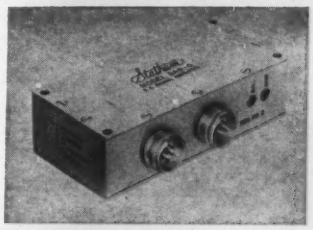
CIRCLE 283 ON READER-SERVICE CARD

DUAL-PURPOSE PRINTER

New IBM 1404, first Printer printing combination of either individual cards or continuous paper forms as direct output from solid-state computer, is for use with 1401 data processing system. Features two document feeding stations and movable chain-printing mechanism. Any size IBM card 51 to 160 columns wide can be printed. If cards are no wider than 80 columns, two cards can be printed side-by-side at the same time. Maximum card output is 800/min when two cards are simultaneously printed with one line of information on each card.—*International Business Machines Corp., Data Processing Div., 112 East Post Rd., White Plains, N. Y.*

CIRCLE 284 ON READER-SERVICE CARD

DC/DC SIGNAL AMPLIFIER

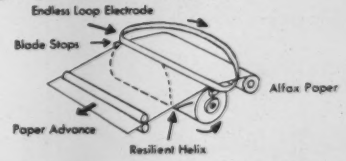


New transistorized high-gain airborne dc-to-dc Signal Amplifier, Model SA9-O, utilizes low-level d-c signals from thermocouples, thermal sensing to bridges, and d-c excited transducers. Gain is continuously variable from 50 to 500 (special models to 1000).—*Statham Instruments, Inc., Electronics Div., 12401 W. Olympic Blvd., Los Angeles 64, Calif.*

CIRCLE 285 ON READER-SERVICE CARD

Instant Graphic Recording

For the first time . . . ultra high speed and precision accuracy in binary graphic display ! 660 inches/second recorded at 40 lines/inch. Sweep information is amplitude measured at .010" against a grid generated at recorder.



Exclusive Alden graphic recording techniques make it simple to synchronize a recording helix with any of a variety of sweep, time-base, sampling, or other sensing applications which involve processing information on a sequential basis.

SAMPLE APPLICATIONS

RADAR — Direct graphic recording from radar or tapes at radar rate or sampling of radar return for range information, azimuth, target identification.

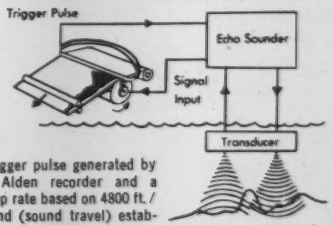
FREQUENCY ANALYSIS — Radio astronomy output records sweep of receiver with dynamic tone shade response identifying frequencies of interest.

INFRA-RED — Integration by Alfax Paper suppresses random noise functions integrates repeat signals.

ULTRASONICS — Specific flaw detection on 1 to 1 basis with wide printout available to 4' width.

SONAR — Echo-ranging, echo-sounding, ASW active & passive systems, etc.

SPECIFIC SONAR APPLICATION



A trigger pulse generated by the Alden recorder and a sweep rate based on 4800 ft./second (sound travel) establish the interval to be recorded. Variable paper feed rate provides integration of signal return.

PRECISION GRAPHIC RECORDER... an example of complete system development. The Alden 419PGR operates at 12 discrete speeds, presents 20 fm to 3000 fm full scale for flexible programming of underwater sound recording.

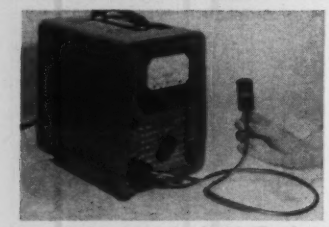
Write for complete information Dept. E3;

ALDEN ELECTRONIC

CIRCLE 107 ON READER-SERVICE CARD

CIRCLE 108 ON READER-SERVICE CARD

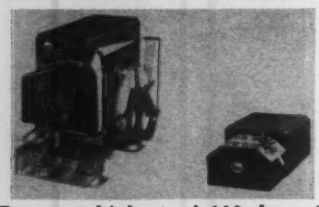
MAGNETIC FIELD EVALUATOR



New AC magnetic field Evaluation Probe operates in conjunction with an a-c VTVM for determining a-c magnetic field intensity. Each unit is individually calibrated in a known field, rms-voltage output is noted as a function of gauss level. Probe consists of air core inductor epoxy cast within an electrostatic shield enclosure.—*Magnetic Shield Div., Perfection Mica Co., 1322 N. Elston Ave., Chicago 22, Ill.*

CIRCLE 286 ON READER-SERVICE CARD

HIGH-SPEED TAPE UNITS



Two new high-speed 100-character-per-second tape units, the BRPE Tape Punch and the CX Tape Reader, operate as a complementary matched pair. The CX reads either fully perforated or chadless tape and adjusts to 5-8 levels. The BRPE is available in 2 models, either for 5-level code or adjustable for 6, 7, or 8 levels. Units operate on parallel-wire signals which can be serialized by Teletype electronic equipment.—*Teletype Corp., Dept. SP--12, 5555 Touhy Ave., Skokie, Ill.*

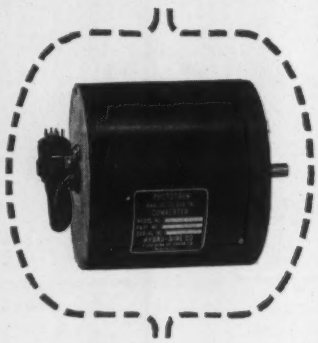
CIRCLE 287 ON READER-SERVICE CARD

MILLIVOLT SOURCE

New Model 205 Precision Millivolt Source is self-contained, direct-reading with full scale outputs of 1000, 100, and 10 mv, 0.1% linearity, 0.1% step attenuator accuracy, and stability of 0.1% per day, after stabilization. Internal mercury battery supplies power for more than 1000 hours of operation.—*Monroe Electronic Laboratories, Inc., 39 Vernon St., Middleport, N. Y.*

CIRCLE 288 ON READER-SERVICE CARD

PHOTOTRON



FIRST IN NEW LINE OF ANALOG TO DIGITAL CONVERSION PRODUCTS FROM HYDRO-AIRE

This highly versatile basic transducer offers incremental conversion of shaft angle to digital measurement. Available in seven models, its maximum permissible speeds range from 15,000 rpm at 128 counts per revolution to 1,250 rpm at 2,048 counts, with sample rates ranging to 45,000 counts per second.

Applications for the Hydro-Aire Phototron include analog to digital shaft converters, precision analog servo with digital readout, data reduction equipment, tachometers, and precision measurement and control.

Detailed specifications are available on request. Related products soon to be available from Hydro-Aire, a member of the Crane Co. Systems and Controls Group, will include associated power supplies and binary and digital counters.

HYDRO-AIRE
DIVISION OF
CRANE

3000 WINONA AVE., BURBANK, CALIF.

CIRCLE 129 ON READER-SERVICE CARD

Look to October 1961 issue of Instruments and Control Systems for expert treatment of this important control topic - - -

• PROCESS INSTRUMENTATION

ICS' READERS can look forward to a comprehensive display of highly informative and useful data.

MANUFACTURERS and designers of associated instrumentation, equipments and components will find this a particularly valuable medium in which to advertise.

For ad and other details, contact our nearest rep — see list on page 1336.

---

for more data on products advertised or reported editorially

1. **CIRCLE THE NUMBER, on one of the cards, that corresponds to the number appearing with the advertisement, new product description or new manufacturer's literature.**
2. **PRINT YOUR NAME, title, company, address, etc. clearly. Unreadable cards defy even punched card machines!**

NOTE: If indicating change of address, be sure to also show OLD address.

Valid only; in U.S., Canada and Mexico; if filled out completely; Until 11-1-61 **August 61**

Name ..... **Title** .....

Company ..... **Address** .....

City ..... **Zone** ..... **State** .....

Principal Product of Your Plant .....

☐ **Check for address change. Show OLD address here:** .....

| | | |

YOUR PERSONAL SUBSCRIPTION

What's in it for you?

A clean crisp copy each month and every month, completely free of "other reader" marks—no clip- or tear-outs—no creased, bent, coffee stained, dog-eared (or chewed) pages.

And . . . you get the full benefit of outstanding editorial material—solid application data, uncensored by the scissor-wielding reader "up the list" from you—news that's still newsy—and unbroken "series" continuity.

Your personal subscription

to INSTRUMENTS & CONTROL SYSTEMS will assure you of receiving the important 1961 special features on the following:

SEPTEMBER—Numerical Control

OCTOBER—Process Instrumentation

NOVEMBER—Analytical Instrumentation and Stream Control

DECEMBER—Current and Voltage Control

Each issue also will include feature articles on other instrument and control subjects, plus the regular monthly features:

Enter your personal subscription now—use the postpaid card above.

ATTENTION CIRCULATION: EXPEDITE THIS PERSONAL CIRCULATION

Instruments & Control Systems
845 Ridge Avenue, Pittsburgh 12, Pa.

OK, start my subscription to I&CS for one full year (12 issues) for only $4.00.

☐ Payment Enclosed ☐ Bill Me

Name _____

Title or Position _____

Company _____

Address _____

City _____ Zone _____ State _____

Principal Product of Your Plant _____

FURNISH COMPLETE DATA FOR FASTEST SERVICE. THANK YOU

FIRST CLASS
PERMIT NO. 1441
PITTSBURGH, PA.

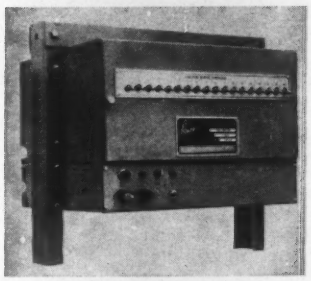
BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY—

INSTRUMENTS and CONTROL SYSTEMS
(Instruments Publishing Co., Inc.)
845 Ridge Avenue
Pittsburgh 12, Pa.

8/61

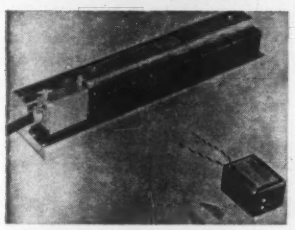
ELECTRONIC SCANNER



New Series B-1000 solid-state Electronic Monitoring System includes transmitter assembly (illustrated) which translates up to 36 On-Off or Start-Stop commands into coded pulses for transmission over telephone line or microwave link. Similar receiver unit provides continuous report on status of controlled functions over same line. Form B1020.—*Lynch Communications Systems Inc., 695 Bryant St., San Francisco 7, Calif.*

CIRCLE 292 ON READER-SERVICE CARD

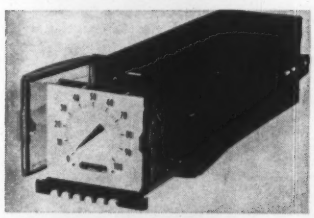
DATA SCANNING RELAY



New Model 224 Data Scanning Relay features electromechanical relay coil, utilizes two replaceable sealed cartridges containing armature and fixed contacts. Magnetic coupling to relay coil permits DPDT configuration; multiplexes microvolt signals, several hundred samples/sec. Bulletin MRL60434.—*Magnavox Research Labs., 2829 Maricopa St., Torrance, Calif.*

CIRCLE 293 ON READER-SERVICE CARD

LEVEL INDICATOR



New 959 Series Capacitance Type Level Indicator for liquids and granular solids accepts signals from up to 6 probe types, indicates and/or controls them in solid-state, 1% accurate Receiver (illustrated). Circuitry consists of self-balancing bridge with servo readout. No coaxial cable required.—*Magnetic Instruments Co., Inc., Thornwood, N. Y.*

CIRCLE 294 ON READER-SERVICE CARD

WHICH VALVE IS OPEN?

They both are . . . but only the Hydromatics ***FLO•BALL 715***, on the right, shows its position at a glance! A fast **quarter** turn moves it from open to closed position—instant action at flow pressures up to 3,000 psi with just 10 inch-pound torque. The ***FLO•BALL's*** exclusive straight-thru design has maximum flow efficiency—more than double the flow of needle valves!

Ideal for leakproof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, etc., the ***FLO•BALL*** features zero leakage, universal mounting, removable flanges, and all stainless steel construction.

Write today for a complete catalog describing this valve and others for corrosive and cryogenic media. Also special designs for throttling flow control.

The *FLO•BALL* costs no more than old fashioned screw-type valves!

FLO-BALL

Hydromatics, Inc.

BLOOMFIELD, N. J. • PILGRIM 8-7000 • TWX—BLOOMFIELD N J 120

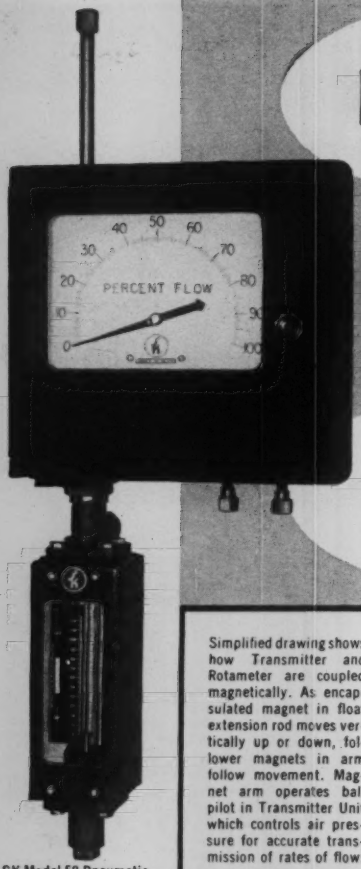
CIRCLE 109 ON READER-SERVICE CARD

NEW

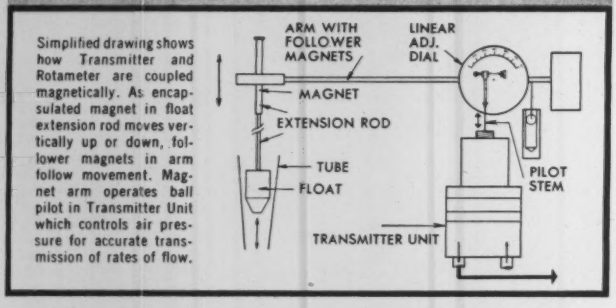
PNEUMATIC TRANSMITTING ROTAMETER

offers

"NEVER-BEFORE" *features*



SK Model 58 Pneumatic Transmitter with SK Safeguard Rotameter.



Simplified drawing shows how Transmitter and Rotameter are coupled magnetically. As encapsulated magnet in float extension rod moves vertically up or down, follower magnets in arm follow movement. Magnet arm operates ball pilot in Transmitter Unit which controls air pressure for accurate transmission of rates of flow.

Here's a new design in Pneumatic Transmitters—the Model 58 by SK's INSTRUMENT DIVISION. Designed for use with either SK Safeguard or Metal Tube Rotameters, these "position-balance" type transmitters communicate fluid rates of flow to remote located indicators, recorders, controllers, or integrators. Here are some of many important advantages offered by the Model 58.

- Calibration adjustments are simple without cams, special devices.
- Exclusive magnet design (patent applied for) provides evenly-distributed field without drag on metering float.
- Transmitter Unit of pneumatically-coupled section design has no mechanical linkages, assures high accuracy.
- Percent scale suitable for any calibration. Factor tag on dial face permits conversion of scale units to flow quantity.
- Varying supply air pressure (between 20 and 25 psig) will not affect accuracy.
- Large scale and pointer permit easy, accurate reading.
- Removal of transmitter not required for cleaning main valve or pilot orifice.

Details on this new Transmitter are covered in Bulletin 18N which is available on request.

QUICK DELIVERY FROM STOCK

For Immediate Delivery, Standard SK Jet Ejectors, Rotameters, and Flow Indicators are stocked in Cornwells Heights (Phila.), Pa., Houston, Texas, and San Francisco, Calif.

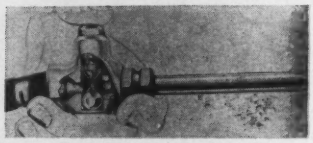
Schutte and Koerting COMPANY

INSTRUMENT DIVISION

2225 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

CIRCLE 110 ON READER-SERVICE CARD

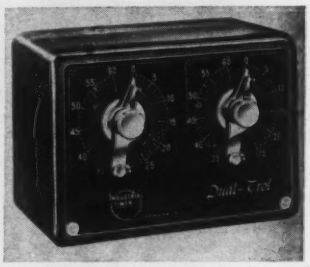
SHEAR-AIR VALVE



New 4", 5-oz Shear-Air Valve incorporates principles of Type Hi-100 ball control valve, delivers powerful air blast with light finger pressure.—*General Kinetics Corp.*, 197 *S. Van Brunt St., Englewood, N. J.*

CIRCLE 295 ON READER-SERVICE CARD

RECYCLING TIMER



New Series Dual-Trol Recycling Timer produces series of "on" and "off" electrical pulses to start and stop process in predetermined sequence. Time interval easily changed; modules available with maximum time ranges from 6 sec to 3 hr.—*Industrial Timer Corp.*, 1407 *McCarter Hwy., Newark* 4, *N. J.*

CIRCLE 296 ON READER-SERVICE CARD

DIFFERENTIAL VOLTMETER

New solid-state Differential Voltmeter, Model 851, features five-dial in-line readout, Zener reference backed up by built-in standard cell, 0-to-10 v dc precision source in 10 μv steps, recorder output, 1 mv to 1 kv range, absolute accuracy better than $\pm 0.05\%$. —*Smith-Florence, Inc.*, 4228 *23rd West, Seattle* 99, *Wash.*

CIRCLE 297 ON READER-SERVICE CARD

ANNUNCIATOR WINDOW BEZEL

New snap-on, alarm-window Bezel permits easy reading and changing of bulbs or nameplates. Standard on new Panalarm Model 51 cabinets. Snaps on existing annunicator systems.—*Panellit, Div. of ISI, Inc., Skokie, Ill.*

CIRCLE 298 ON READER-SERVICE CARD

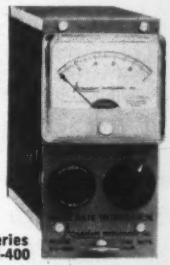
For Frequency Measurement

PULSE RATE INTEGRATORS

by Anadex

Series PI-100
Frequency indicators and frequency deviation indicators

Series PI-300
Precision frequency-to-dc converters for telemetry and other aircraft and missile uses.



Series PI-400
Precision plug-in module frequency-to-dc converter and indicator. Six may be mounted in 19" rack.

Designed For Use With

- **Turbine Flow Sensors**
- **Tachometers**
- **Rotating Machinery**
- **Repetition Rate Pick-ups**
- **Radiation Detectors and other frequency generating devices**

Here is a complete, all new line of versatile, reliable Pulse Rate Integrators especially designed for accurately converting a frequency or pulse rate to an analog output of dc voltage or current, or to a visual meter indication. Featuring many different models for the widest range of applications, these Anadex instruments represent the ultimate in dependability and operating performance.

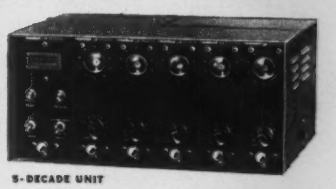
Visit Our Booth 104 ISA Show

Anadex INSTRUMENTS INC.
14734 Arminta St., Van Nuys, Calif.

CIRCLE 111 ON READER-SERVICE CARD

accelerate production,

improve accuracy, cut costs with



5-DECADE UNIT

Tally-COUNT®
electronic predetermining counter

Tally-COUNT automatically counts precise units into a container . . . determines exact footage from a roll . . . stops and recycles machine operations at preset counts, at electronic speeds.

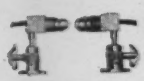
Tally-COUNT is actuated by external contacts or electronic impulses, control relay operates required mechanism: solenoid, motor, cut-off knife, etc.

Optional **plug-in** accessories: Batch Register, Photo-Electric Eyes, Footage Counters, Multiple Pre-Set Decades.

SPEEDS OPERATION
ELIMINATES GUESSWORK
BOOSTS PRODUCTION

Count, inspect, control production AUTOMATICALLY

ROBOT-EYE PHOTO-ELECTRIC CONTROLS



Plug-in relays, receptacles for plug-in connection of time delays, lamps and cells.

Write for Brochure JC-8

standard INSTRUMENT CORPORATION
657 BROADWAY, NEW YORK 12, N. Y.

CIRCLE 113 ON READER-SERVICE CARD

OUR 33rd YEAR

"PYROMETEERS"

PYROMETER ENGINEERS, BUYERS, EXECUTIVES

attending the Los Angeles ISA Show we invite you to our

BIG PARTY ★ STATLER HOTEL

★ See Our Gigantic Floor Show
★ Big Bar
★ Big Buffet Supper
★ 10 pc. Orchestra—Dancing ★ Beautiful Girls—Side Attractions

PACIFIC BALLROOM

Just a short walk from the Auditorium

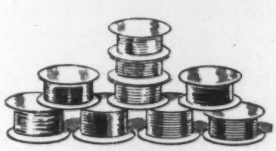
Thursday, Sept. 14, 9:00 p.m. till 2:00 a.m.

SEE OUR BOOTH . . . NUMBER 445, LOS ANGELES SPORTS ARENA
BY INVITATION ONLY. PICK UP INVITATION AT OUR BOOTH

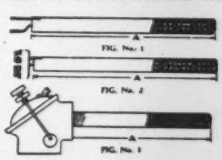
INDUSTRIAL PYROMETER & SUPPLY CO.

ALTON, ILL. U.S.A.

WORLD'S OLDEST ACTUAL MANUFACTURER OF PYROMETER & THERMOCOUPLE EXTENSION LEAD WIRE.

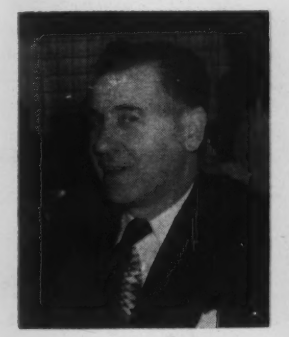


WIRES



THERMOCOUPLES

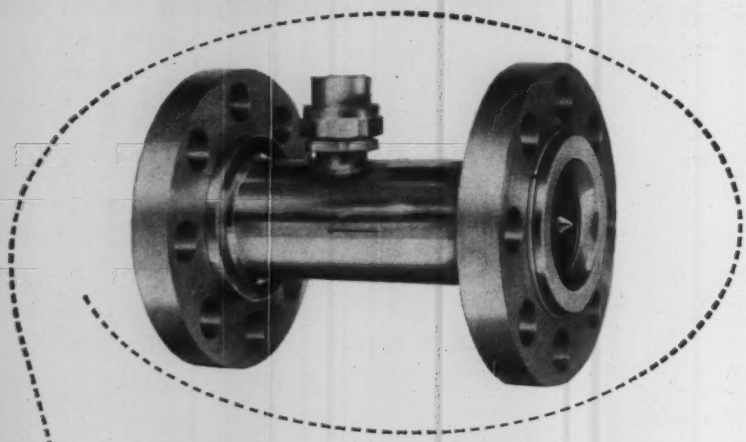
THERMOCOUPLE LEAD WIRES



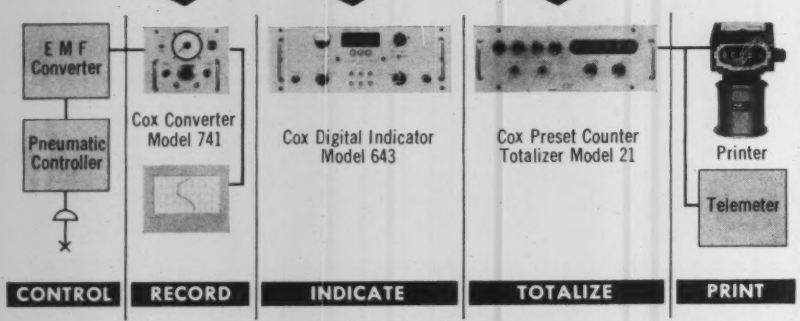
Avery Hack, Pres.

CIRCLE 112 ON READER-SERVICE CARD

Start Right!



with **COX Turbine Flowmeters**



The most important element in any flow measurement or control system is the *primary* transducer. Start with a good signal and the final readout or control will be good. And, as many users are finding, a good way to start is with Cox Turbine Flowmeters. Here's why—

Signal output versus flowrate is extremely stable and is *±1/4% or better of actual flowrate* with rangeability as high as 65:1. Besides, Cox turbine flowmeters are rugged . . . usable with most fluids at extremes of temperature and pressure . . . and *are easily disassembled for cleaning in a matter of seconds without affecting calibration.* To insure complete system accuracy, Cox also builds auxiliary readout and control equipment.

For more information write *Cox Instruments, George L. Nankervis Company, 15300 Fullerton Avenue, Detroit 27, Michigan.*

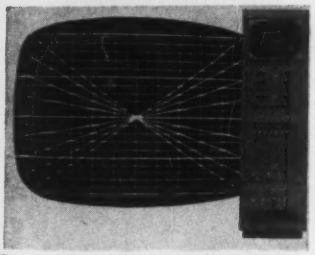
Write for Handbook on Cox Turbine Flow Measurement and Control Systems No. 3000.

COX INSTRUMENTS
GEORGE L. NANKERVIS COMPANY
Representatives in principal cities.

Subsidiary of PENINSULAR METAL PRODUCTS CORP.

CIRCLE 114 ON READER-SERVICE CARD

DISPLAY SYSTEM



New Model 5934 Multi-Channel Calibrated Display System displays simultaneously on a 17" CRT up to eight input signals superimposed on an electronically-generated coordinate system. Because signal waveforms and coordinate system are displayed simultaneously, errors from distortion and non-linearity are eliminated. Accuracy 0.2%. With three modes of operation, it can synchronize an external device with start of its display period; it can be synchronized by an external device; or it can be used in systems analysis as a cross plotter.—*Philbrick Researches, Inc., 127 Clarendon St., Boston 16, Mass.*

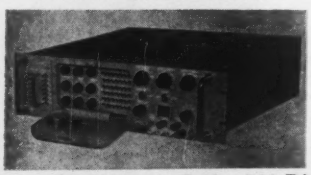
CIRCLE 299 ON READER-SERVICE CARD

FREQUENCY STANDARD

New Model X-4700 Rubidium Vapor Frequency Standard, quantum electronic device based on optical pumping and transmission monitoring, features long term stability of 2 parts in 10^{10} and short term stability of 3 parts in 10^{11} for 1-sec sampling time. Standard output frequencies are 5.0, 1.0 and 0.1 Mc. Data sheet.—*Varian Associates, 611 Hansen Way, Palo Alto, Calif.*

CIRCLE 300 ON READER-SERVICE CARD

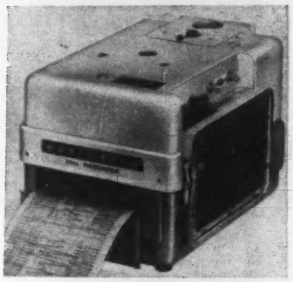
PULSE SIMULATOR



New all-solid-state Series 500 Digital Electronic Signal Simulator permits test of digital communications systems, use as memory exerciser and programming device for computers in data reduction centers. Presents data in serial form of any type of digital coding, simulating digital output of multiplexer or digitizer in RZ, NRZ and modified NRZ formats.—*Telemetrics, Inc., 12927 S. Budlong Ave., Gardena, Calif.*

CIRCLE 301 ON READER-SERVICE CARD

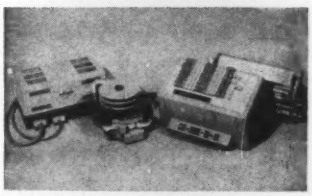
VISICORDER WITH BUILT-IN TIMER



New direct-recording Oscillograph Visicorder 906C has optional built-in flash tube timer that produces full-width time lines on recording paper at any of three intervals. Timing circuit triggers externally by pulsing voltage of 10 v at 20K ohms impedance, or by causing impedance to drop to 100 ohms or less. Two timing systems—Types X and M can be installed in Visicorder 906, 906A and 906B models.—*Minneapolis-Honeywell, Heiland Div., 5200 E. Evans Ave., Denver 22, Colo.*

CIRCLE 302 ON READER-SERVICE CARD

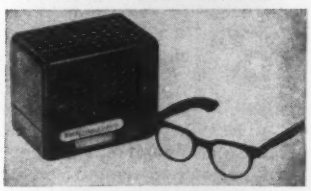
LINE PRINTERS



Two new line Printers, Model M C208 for preparation of hard copy and punched tape or punched card output and Model MC 206 without punched output, accept data electrically or by manual entry. Feature self-contained timing relays, cycling speed of 145 cpm (printing only) or 60 cpm printing and punching 14-digit word with automatic insertion of indicative codes.—*Monroe Calculating Machine Co., Inc., Electronics Components Div., 60 Main St., San Francisco 5, Calif.*

CIRCLE 303 ON READER-SERVICE CARD

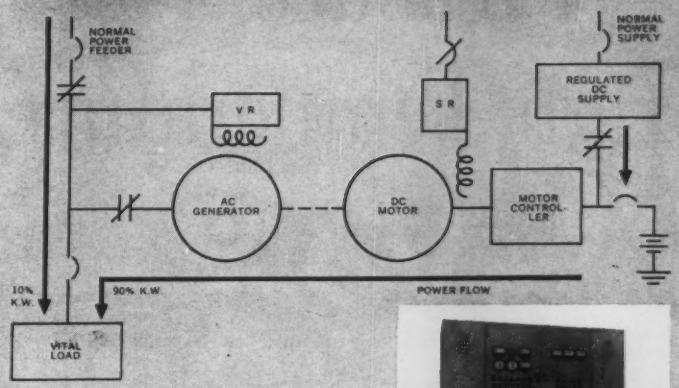
SYMBOL GENERATOR

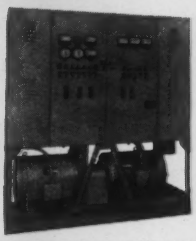


New Series C36000 solid-state Character Generator, the Curviline, can be used with any CRT display. Alphanumeric unit writes to 200,000 characters/sec; combines straight and curved lines to form digits, letters, symbols.—*RMS Associates, Inc., 805 Mamaroneck Ave., Mamaroneck, N. Y.*

CIRCLE 304 ON READER-SERVICE CARD

AN AMMONIA PLANT APPLICATION...





In the installation pictured, the rating of the AC generator is 12 KW, .8 power factor, 1 phase, 60 cycle, 460 volt.

ANOTHER EXAMPLE OF HOW KEARFOTT ASSURES CONTINUOUS, UNVARYING POWER FOR CONTROL EQUIPMENT AND INSTRUMENTATION

The heavy losses which can occur when power interruptions or fluctuations affect the control equipment and instrumentation in manufacturing processes, are effectively prevented by Kearfott Uninterrupted Power Systems. The system described below, used in an ammonia plant, is typical of many now in use, all with a perfect record for reliability.

In this particular system, a DC motor drives an AC generator, the output of which is the same as the normal available power. Meanwhile, the DC power that runs the motor also keeps the batteries in fully charged condition. When failure of the prime power occurs, the motor continues to run on the batteries, and the AC generator continues to meet the vital power load requirement. Controls and instrumentation continue without interruption. Voltage and frequency are regulated to within ±1% of rated values, regardless of variations in normal power supply input.

Kearfott's compact uninterrupted power equipment combinations are also available in 2 and 3 unit systems operating in parallel with or isolated from the line. Provisions may be had for audible and/or visual alarms to indicate over- and under-voltage, overload or ground conditions.

Generator ratings to 150 KVA 60 and 400 cycles, single and polyphase. Frequency, voltage and transfer regulations as required by the application.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

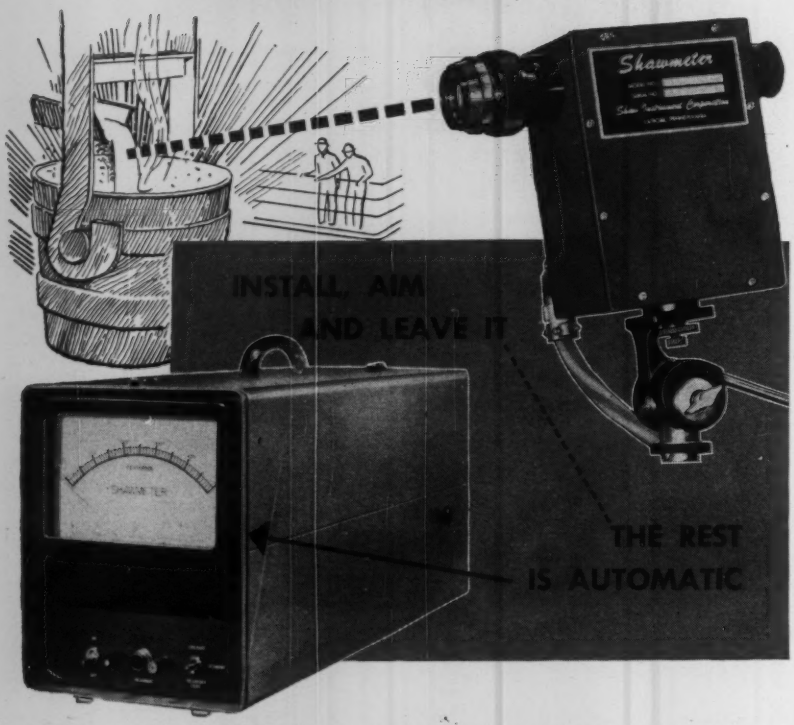
CIRCLE 115 ON READER-SERVICE CARD

Measure High Temperatures

EASILY, ACCURATELY

with the

SHAWMETER®



The SHAWMETER is an automatic, direct-reading, two-color pyrometer for indicating, recording or controlling temperatures up to 6500°F.

Measures the temperature of flowing metal, or of moving or stationary objects. No emissivity correction needed. Temperatures may be measured at a considerable distance from the object.

Accurate, sensitive, rugged. Write for complete details.

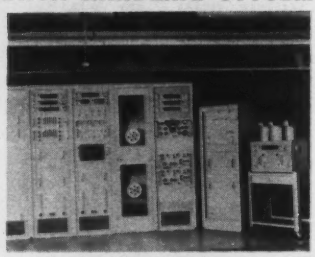
SHAW INSTRUMENT CORPORATION

CERAMIC-METAL SEALS • NUCLEAR and ELECTRONIC INSTRUMENTATION

P. O. Box L-46 Latrobe, Pennsylvania

CIRCLE 116 ON READER-SERVICE CARD

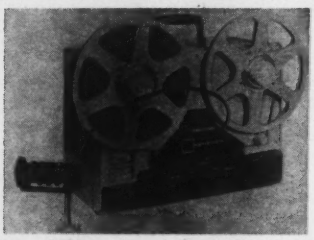
DATA HANDLING SYTSEM



New antenna-position Data Handling System provides and records digital representation of angular position of the axes of an equatorially-mounted radio tracking antenna. Also generates and records time, records Doppler frequency, data condition, and parameter data.—*Datex Corp., Box* 667, 1307 *S. Myrtle Ave., Monrovia, Calif.*

CIRCLE 305 ON READER-SERVICE CARD

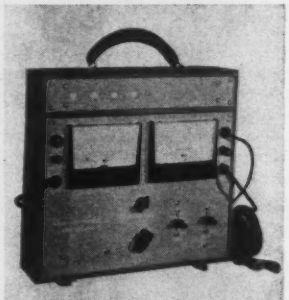
COUNTER ON TAPE RECORDER



New "Y"-series 4-digit Instrument Counter is used to indicate exact tape position in the Magnecord 728 "Professional" tape recorder. Driven by V-belt from axle of payout reel with accuracy to fraction of an inch.—*Durant Mfg. Co.*, 1914 *N. Buffum St., Milwaukee* 1, *Wis.*

CIRCLE 306 ON READER-SERVICE CARD

INSULATION TESTER



New Model 2955 Vibrotest for dielectric absorption tests and plotting of insulation-resistance-vs-time curves has d-c test potential continuously adjustable over complete range 0 to 2500 vdc, allowing comparison of insulation resistance at any selected voltages. Electronic power supply, operating from batteries, provides d-c high-voltage test potential, eliminating a hand-crank style magneto. Range 100,000 ohms to 50,000 megohms.—*Associated Research, Inc.*, 3777 *W. Belmont Ave., Chicago* 18, *Ill.*

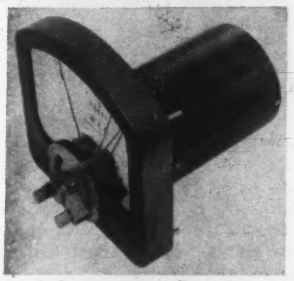
CIRCLE 307 ON READER-SERVICE CARD

VIBRATION MEASUREMENT

New Vibration Measuring System (VMS) for use in sinusoidal laboratory vibration testing creates exact slow-motion replica of accelerometer signals while signal sweeps from 10 cps to 10 kc. Replica can be recorded on any low-speed oscillograph.—*Chadwick-Helmuth Co., 472 E. Duarte Rd., Monrovia, Calif.*

CIRCLE 308 ON READER-SERVICE CARD

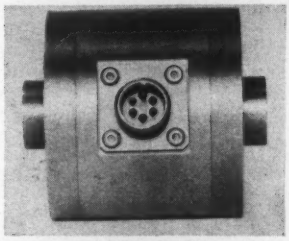
GALVANOMETER SERVOMETER



New Galvanometer Servometer System is a galvanometer indicator with a position servo system utilizing a precision film potentiometer; full scale accuracy of 0.25% is maintained under shock, vibration, and varying temperatures. Has 50-msec max full scale response time. Details in bulletin.—*Computer Instruments Corp., Servometer Products Div., 92 Madison Ave., Hempstead, N. Y.*

CIRCLE 309 ON READER-SERVICE CARD

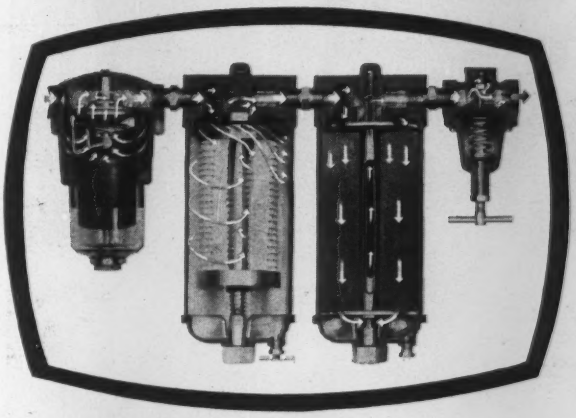
PRESSURE TRANSDUCER



New Type 4-351, in line of strain-gage Pressure Transducers for high-line, bidirectional, low-differential service, features line pressure rating of 5000 lb with less than 1% full range shift from zero to 5000 psi, differential pressure range ±15 psid to ±100 psid. Is suitable for orifice-plate flowmeter applications.—*Consolidated Electrodynamics Corp., Subs. of Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 310 ON READER-SERVICE CARD

NEW DEHYDRATOR



package provides "instrument pure" compressed air only where needed

The WILKERSON "Chem-Guard"

is available singly or in a package as illustrated

EXCLUSIVE FEATURES

- ★ Lowest price
- ★ Dependability assured
- ★ Simplified, economical servicing
- ★ Built-in visible indication of affluent air relative humidity

for complete information on the NEW "Chem-Guard", Circular #1043.

WRITE TODAY
1619 W. Mansfield, Englewood, Colo.

WILKERSON CORPORATION

Dedicated to keeping the NEW in pNEUmatics

CIRCLE 117 ON READER-SERVICE CARD

REGULATES PRESSURE TO .0005%!

. . . the most sensitive vernier pressure regulator ever designed to set exact pressure in non-flow or trapped systems using air or other gasses.

By varying volume to regulate pressure, the Vernator is used in calibrating manometers, dead weight testers, precision gages, barometers, transducers and other precision test equipment over a dynamic pressure range of 0-500 psi. Replaces expensive complex valving systems and conventional regulators in many applications. Because of the unusual principal employed the Vernator can also be used as a vacuum or pressure generator over a limited range.

WRITE FOR COMPLETE INFORMATION TO:

Limited Distributorships Available

Astromics
A DIV. OF MITCHELL CAMERA CORP.

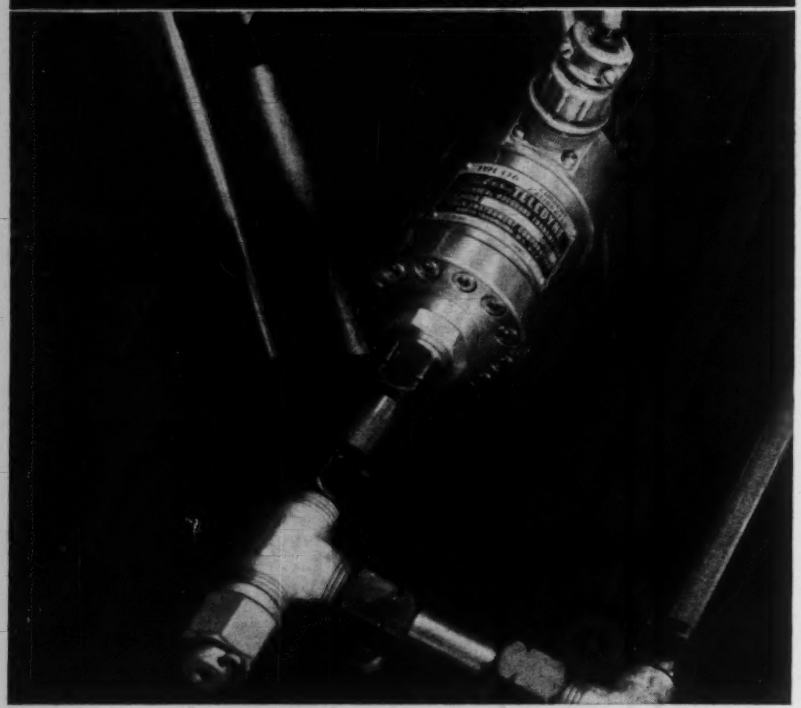
666 West Harvard Street
Glendale, California

CIRCLE 118 ON READER-SERVICE CARD

Taber®

TELE-NEWS

ABOUT TELEDYNE AND TELEFLIGHT PRESSURE SYSTEMS



Taber Transducer logs 1,500,000 cycles in Pall filter tests without repair

The sensitivity, continuous performance and economical life of Taber bonded strain gage pressure transducers are proved in test operations at Aircraft Porous Media, Inc., a subsidiary of Pall Corporation, Glen Cove, N. Y.

This leading manufacturer of porous stainless filters uses Model 176 Taber Teledyne Pressure Transducers in fatigue testing pneumatic and hydraulic filter units for missiles, aircraft, and atomic submarines. During these tests, pressure pulses from zero to 10,000 psi are sensed and recorded on an oscilloscope at a rate in excess of 150 cycles per minute. Rate of pressure rise is in the range of 200,000 to 300,000 psi per second. The unit shown above has been in operation in excess of 1½ million cycles *without repair or overhaul.*

For full information on Taber Transducers (in pressure ranges from 0-50 to 0-10,000 psi) for test, ground support, and airborne applications, send this coupon attached to your letterhead.

TO: TABER INSTRUMENT CORPORATION
AEROSPACE ELECTRONICS DIVISION SECTION 243
107 Goundry Street, North Tonawanda, N. Y.

Send detailed information on Taber Teledyne and Teleflight bonded strain gage pressure transducers.

name _____ title _____

company _____ dept. _____

address _____

city _____ zone _____ state _____

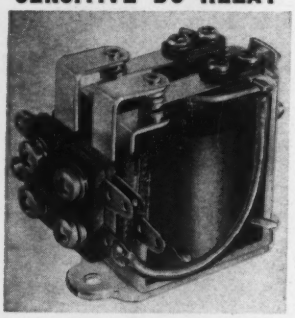
CIRCLE 119 ON READER-SERVICE CARD

ANGULAR ACCELEROMETERS

New AA-Series of Angular Accelerometers senses roll, pitch, and yaw. Five models cover angular acceleration from 0.5 to 500 rad/sec². Resolution is better than 0.01% of full scale.—*Dynamic Measurements Co., 106 Terwood Rd., Willow Grove, Pa.*

CIRCLE 311 ON READER-SERVICE CARD

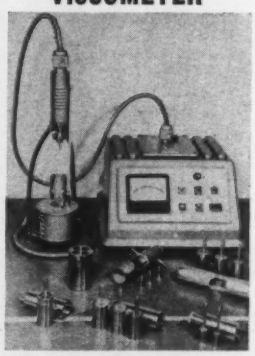
SENSITIVE DC RELAY



New SP-Series Sensitive DC Relay has standard operating power of 100 mw for 1C (SPDT) and 200 mw for 2C (DPDT) contacts. Special adjustments enable sensitivities as low as 15 mw for 1C and 70 mw for 2C. 2" x 2⅛" x 1¾".—*Elgin Advance Relays, Electronics Div., Elgin National Watch Co., 2435 N. Naomi St., Burbank, Calif.*

CIRCLE 312 ON READER-SERVICE CARD

VISCOMETER



New Rotating Viscometer features four coaxial-cylinder (cup-and-bob) systems and a plate-cone measuring system, has range of 5 x 10^{-3} to 4 x 10^{7} poises, permits scientific rheological studies, and rapid individual or continuous routine tests. Bulletin BR-58 gives details.—*Brinkmann Instruments, Inc., 115 Cutter Mill Rd., Great Neck, N. Y.*

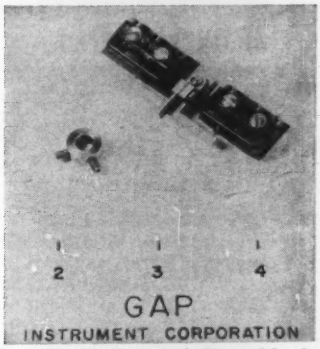
CIRCLE 313 ON READER-SERVICE CARD

HI PRESS REGULATOR

New 16500 Series High Pressure Regulator controls 100-4000 psig input at 15-300 psig within ±0.2 psi, withstands tremendous pneumatic shocks, is insensitive to flow- or inlet-pressure changes.—*Aerodyne Controls Corp.*, 90 *Gazza Blvd., Farmingdale, N. Y.*

CIRCLE 314 ON READER-SERVICE CARD

ELECTRICAL LIMIT STOP



New Limit Stop is adjustable from 20 to 370 degrees. Operating torque is 0.5 in-oz, capacity is 5 amp, 250 vac, differential angle is —4°. Bulletin Form 142.—*Gap Instrument Corp., S. Main St., Newtown, Conn.*

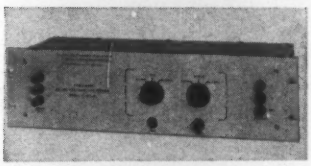
CIRCLE 315 ON READER-SERVICE CARD

MINI BALL VALVES

New line of Miniature Ball Valves is available for both manual and motorized operation and can be used in place of needle valves, pet cocks, etc. Made for panel mounting in 1.8", ¼", ⅜" and ½" sizes and available in Type 316, 304, stainless steel with Teflon seats and packing as standard, and max pressure rating of 1000 psig. —*Valve & Fitting Div., Cooper Alloy Corp., Hillside, N. J.*

CIRCLE 316 ON READER-SERVICE CARD

AC/DC CONVERTER



New AC-DC Converter Model C-100AR features accuracy of ±0.15% absolute from 0.5 to 1000 vac, solid-state circuitry, and frequency range 30 cps to 10 kc. Ideal for differential and digital voltmeters.—*Calibration Standards Corp.*, 1025 *Westminster Ave., Alhambra, Calif.*

CIRCLE 317 ON READER-SERVICE CARD

Accurate long-distance transmission of specific gravity recordings is no longer a problem with any of the new RMT Models of Arcco-Anubis Recording Gravitometers for recording and transmitting liquid gravity records. These instruments combine the mechanism of the standard Arcco Liquid Gravitometer with a metameter telemeter transmission system which records and transmits the specific gravity record to control room or other remote location. The inter-connecting line may be any two-wire electrical circuit or its equivalent: private wires, telephone circuits, carrier current channels, or radio (VHF or UHF).

The range of the standard instrument is .15 or larger, but instruments with ranges of .10 or .05 can be supplied. Charts are available for more than 75 different ranges of Specific Gravity or Degree A.P.I. Special ranges can be furnished at slight additional cost.

ARCCO Send For Bulletin No. 111-R4

INSTRUMENT COMPANY, INC.

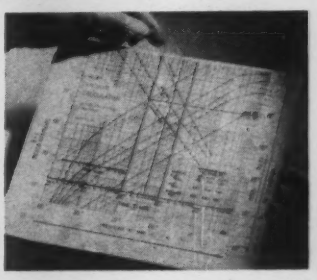
7144 EAST CONDOR STREET · LOS ANGELES 22, CALIF.

MANUFACTURERS OF PRECISION INSTRUMENTS

CIRCLE 120 ON READER-SERVICE CARD

HI-VAC CALCULATOR

New slide-rule-type High-vacuum Calculator for determining pump or chamber size, time and pressure in high vacuum systems consists of two heavy-gage slides held in place by rigid vinyl casing. "First calculator for solving complex high-vacuum problems."—*Consolidated Vacuum Corp., Subs. Consolidated Electrodynamics/Bell & Howell*, 1775 *Mt. Read Blvd., Rochester* 3, *N. Y.*

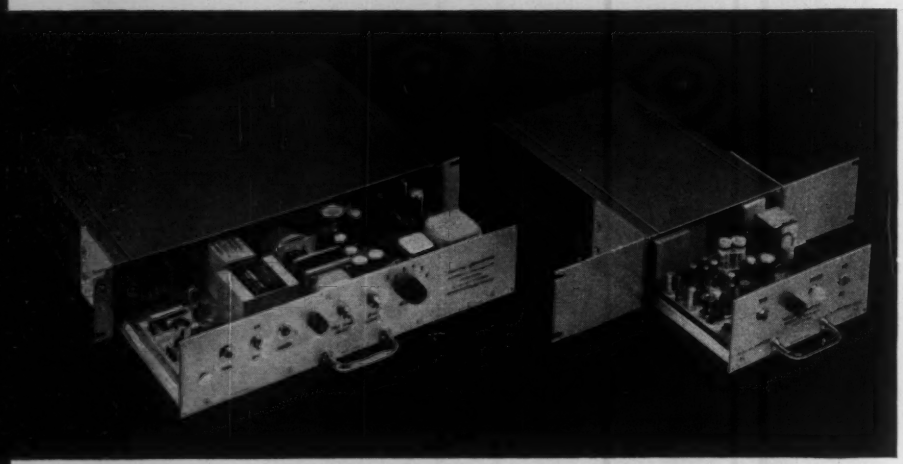


CIRCLE 318 ON READER-SERVICE CARD

NEW GENERAL ELECTRIC

Transistorized Analog

FREQUENCY TELEMETERING OFFERS GREATER SPEED OF RESPONSE, INCREASED ACCURACY



Now available! General Electric's all-new Analog Frequency Telemetering System provides greatest possible *FLEXIBILITY* to meet utility load dispatching and industrial data transmission applications.

Universal design can be easily modified for varying applications resulting in system simplicity and flexibility. Manufacturing standardization assures quick delivery.

Optional plug-in audio-tone equipment permits transmission of data over voice or microwave channels where tone frequencies are required. Optional tone transmitter and receiver offer forty different tone frequencies available with conventional shift-type operation.

Completely transistorized system has *no* vacuum tubes. Telemeter transmitter, tone transmitter and receiver use only transistors in their circuitry. Telemeter receiver utilizes only diodes.

Compact System rack mounts—conserves valuable panel space.

Plug-in application adapters determine input range and output signals for both the transmitter and receiver. Plug-in filters and transformers select tone frequencies.

Combined accuracy of transmitter and receiver is ±0.5 percent of full span over these variations: ± 15°C temperature, ± 5 percent voltage change, ± 3 cycles frequency. A combined accuracy of ± 1 percent of full span is assured even when the transmitter is subjected to −20 to 55°C or ± 10 percent voltage change.

System stability—±0.5 percent of full span in six months plus ±0.1 percent of full span per each subsequent six months.

Quick response—system speed of response is rated 1 second for 99 percent of scale range—practically instantaneous. Such response is invaluable in applications involving load-frequency control wherein high-speed response is essential. In addition, there is no overshoot.

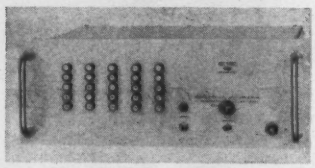
For utility telemetering in transmitting rapid fluctuation of electrical quantities such as watts, vars, volts and amperes . . . for fast positive transmission of industrial process data including quantities of pressure, temperature, liquid level, flow and many others . . . check into the cost saving advantages of G.E.'s new Analog Frequency System today. Your nearest G-E sales representative will be glad to provide you with additional information on this all-new low cost system. Be sure to ask for bulletin GEA-7163, or write direct to General Electric Company, Section 599-07, Schenectady 5, N. Y.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 121 ON READER-SERVICE CARD

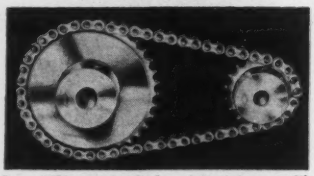
PROGRAMMABLE SCANNER



New Model DY-2901 Input Scanner/Programmer sequentially transfers information from thermocouples, thermistors, strain gages, and other sources to one set of measuring and recording equipment. Features quick-disconnect signal connectors and pushbutton channel selection. Accepts up to 25 inputs, or a total of 100 channels with slave units.—*Dymec Div., Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 319 ON READER-SERVICE CARD

CHAIN/SPROCKET



New Micropitch bushing-type Chain and Sprocket Drives with 0.1475" pitch feature stainless-steel chains with choice of 11 sprockets of 8 to 48 teeth, permitting 121 different speed ratios.—*Diamond Chain Co., Dept. M, 402 Kentucky Ave., Indianapolis 7, Ind.*

CIRCLE 320 ON READER-SERVICE CARD

INCLINED-TUBE MANOMETERS

New economy line of Inclined-tube Manometers is available with vertical ranges 2" to 20", and with scale length 20" to 60" calibrated to the particular manometer. Maximum working pressure is 100 psig.—*King Engineering Corp., Box 745, Ann Arbor, Mich.*

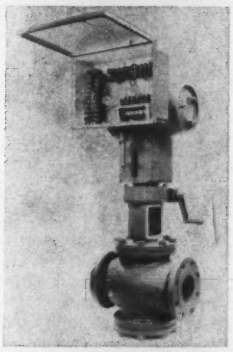
CIRCLE 321 ON READER-SERVICE CARD

PRESSURE CONTROLLER

New Pressure Controller features single-knob proportional band adjustment. Available from stock, both direct acting (Type PDAP) and reverse acting (Type PRAP).—*Leslie Co., 120 Delafield Ave., Lyndhurst, N. J.*

CIRCLE 322 ON READER-SERVICE CARD

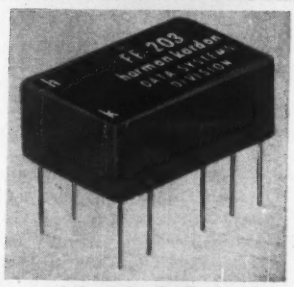
ELECTROHYDRAULIC ACTUATOR



New control circuit variations in electrohydraulic "Hydramotor" Valve Actuator line allow actuator to hold its "last position" in event of main power failure. Actuator then responds to a secondary or emergency power source when such response is required.—*Industrial Controls Div., General Controls Co.,* 801 *Allen Ave., Glendale* 1, *Calif.*

CIRCLE 323 ON READER-SERVICE CARD

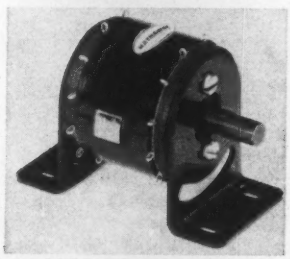
DIGITAL LOGIC MODULES



New miniaturized Series-200 Encapsulated Digital Logic Modules are rated for operation dc to 250 kc and for MIL-E-5272 D temperature range (−54° to +71°C). Epoxy-encapsulated.—*Data Systems Div., Harman-Kardon, Inc., Ames Court, Plainview, N. Y.*

CIRCLE 324 ON READER-SERVICE CARD

COMMUTATOR



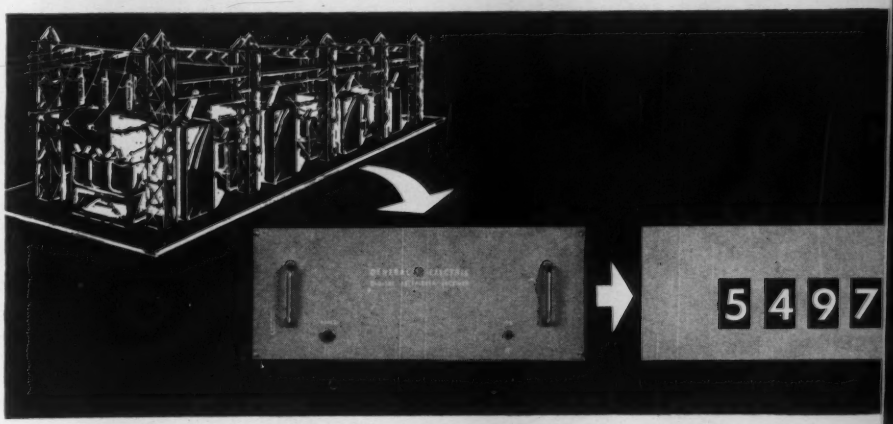
New MCA Commutator employs Drireed contacts actuated by one or more ball-bearing-mounted, rotating magnets which may be driven at speeds up to 30 rps. Very low torque (1 inch-gram for 1 pole/12 channel unit) is featured.—*Hathaway Denver Div., Hathaway Instruments, Inc.,* 5800 *East Jewell Ave., Denver, Colo.*

CIRCLE 325 ON READER-SERVICE CARD

NEW GENERAL ELECTRIC

Digital Telemetering

SYSTEM FOR FAST, HIGH ACCURACY DATA TRANSMISSION



For fastest, most accurate utility load or billing information, General Electric's all-new Digital Telemetering System brings kilowatt-hour information into load dispatching office over one channel, with *100 PERCENT ACCURACY*. Offers outstanding system values . . .

Flexibility: Digital telemetering signal can be time-multiplexed with an analog telemetering signal at a preset time interval, thus providing minimum channel expense and lower operating costs. Or the digital telemetering system can be used over its own isolated channel to transmit information on command. This system will also operate over any intermediate channel equipment capable of accommodating standard analog "frequency" telemetering signals.

Accuracy: Digital receiver self-checking feature permits only the read-out of correct numbers.The receiver will cancel the readout if there has been an incorrect code or interference of the coded signal during transmission.

Speed: Digital transmission is in the form of long and short pulses at average rate of 10 cps. A six digit number can be telemetered in less than five seconds.

Design: System utilizes time-proved relays and stepping switches that require minimum maintenance. No tubes or transistors are used. Equipment is furnished in 19-inch rack, dust-proof cases with slide-out drawers.

Cost: System price is usually less than the cost of comparable integrating devices which it now obsoletes.

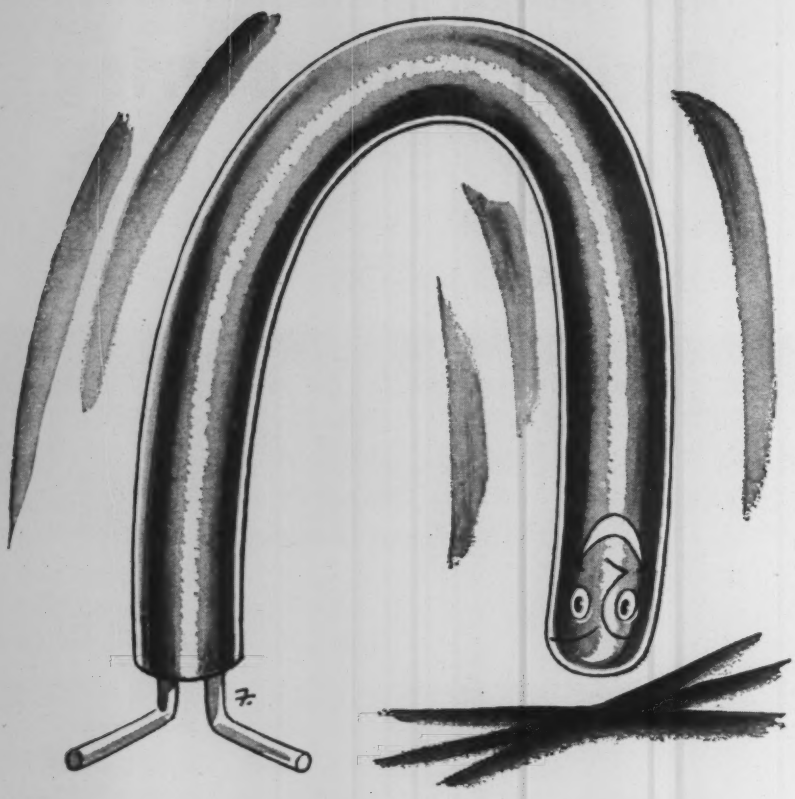
Various read-out devices are available depending on your requirements. These include: electric typewriter, visual digital display units and tape punch equipment if you wish to use the information in a digital computer. Digital transmitters and receivers can be provided for either 4, 6 or 8 digit numbers.

For additional information on the all-new G-E Digital Telemetering System, just call your nearest General Electric sales office, ask for a copy of bulletin GEZ-3312, or write direct to General Electric Company, Section 599-07A, Schenectady 5, N. Y. In Canada, contact Canadian General Electric Company Ltd., 940 Lansdowne Avenue, Toronto 4, Ontario.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 122 ON READER-SERVICE CARD



Ceramo®* Thermocouples will bend over backwards to fit your job!

All of us "Ceramo*-Couples" can bend to almost any configuration, and we don't break our skins, or lose insulation either! When they put us together, they did the job "right."

Over ten years ago, Thermo Electric invented us. Since then, we've multiplied to so many types and sizes that we can do almost any job — and do it better too! We measure temperatures from minus 450°F to 4000°F and higher. Pressures up to 50,000 psi. don't bother us either. We're rugged! We always give you accurate, fast, sensitive and stable temperature readings.

Find out about our whole family —

WRITE TODAY FOR YOUR THERMOCOUPLE CATALOG TC — 12

More than 48 pages of profitable information on every type of Thermo Electric Thermocouples.

*Ceramo® — Thermo Electric's ceramic insulated, metal sheathed thermocouple wire.

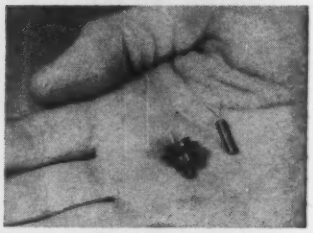
Thermo Electric

THERMO ELECTRIC Co., Inc., Saddle Brook, New Jersey
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

20 YEARS • *Temperature Measuring Systems and Components*

CIRCLE 123 ON READER-SERVICE CARD

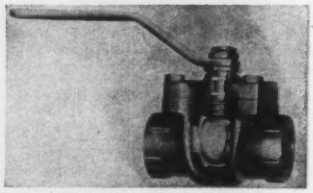
CRYOGENIC SENSORS



Two new Cryogenic germanium semiconductor Sensors, each about the size of a five-cent piece, have temperature range 4° to 40° Kelvin (−269° to −233°C). One type measures surface temperatures; the other is a probe-type unit. Can be used with conventional millivolt-type instruments.—*Minneapolis-Honeywell Regulator Co., Primary Sensors Dept. C189, Wayne & Windrim Aves., Phila-44, Pa.*

CIRCLE 326 ON READER-SERVICE CARD

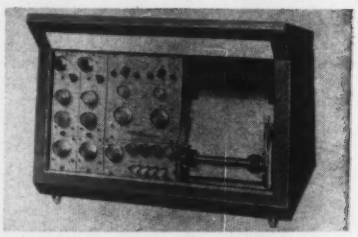
BALL VALVES



New "Fire-Seal" Seats, providing tight shutoff of flammable or dangerous fluids for ball valves, consist of a primary seat of metal-encaged reinforced Teflon incorporating an accurately machined secondary metallic seating surface. If the reinforced Teflon is destroyed by excessive heat, shutoff of flow is insured by metal-to-metal contact between ball and secondary seat.—*Hills-McCanna Co., 400 Maple Ave., Carpentersville, Ill.*

CIRCLE 327 ON READER-SERVICE CARD

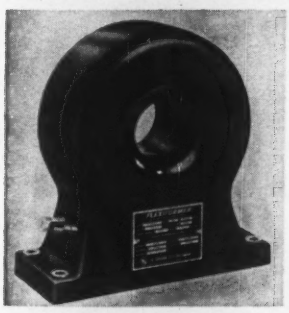
DIRECT WRITING RECORDER



New transistorized, 2-channel Type RS Dynograph features new electrical push button selector for four paper speeds. (1, 5, 25, and 125 mm/sec). With Type 461 preamplifiers, differential input with sensitivities of up to one mv/mm is provided; without preamplification sensitivity is 1 mv/mm single-ended. Rectilinear heat or electric, and curvilinear ink or electric recording media can be employed. —*Offner Electronics Inc., 3900 River Rd., Schiller Park, Ill.*

CIRCLE 328 ON READER-SERVICE CARD

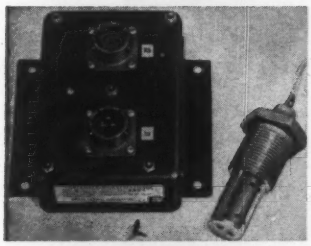
TRANSFORMER PRIMARY



New high-capacity Flexiformer Packaged Transformer Primary Type TP1000 is used as temporary or permanent source of a-c voltage or current transformer. Bulletin SE-L36153. —*Superior Electric Co., Dept. TP*1000, *Bristol, Conn.*

CIRCLE 329 ON READER-SERVICE CARD

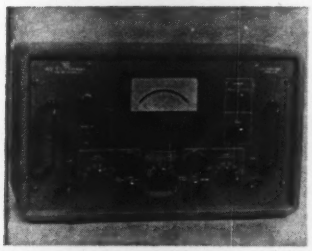
LIQUID LEVEL SENSOR



New cryogenic Liquid Level Sensor and solid-state Control unit utilizes a heat wire to sense the difference in cooling effects between liquid and vapor phases of a cryogenic medium. Static accuracy in rising or falling fluid is ±0.06". Time response for the system in liquid rising at 1" sec is 0.5 sec max.—*United Control Corp., Overlake Industrial Park, Box* 3104, *Seattle* 14, *Wash.*

CIRCLE 330 ON READER-SERVICE CARD

VECTOR ANALYZER

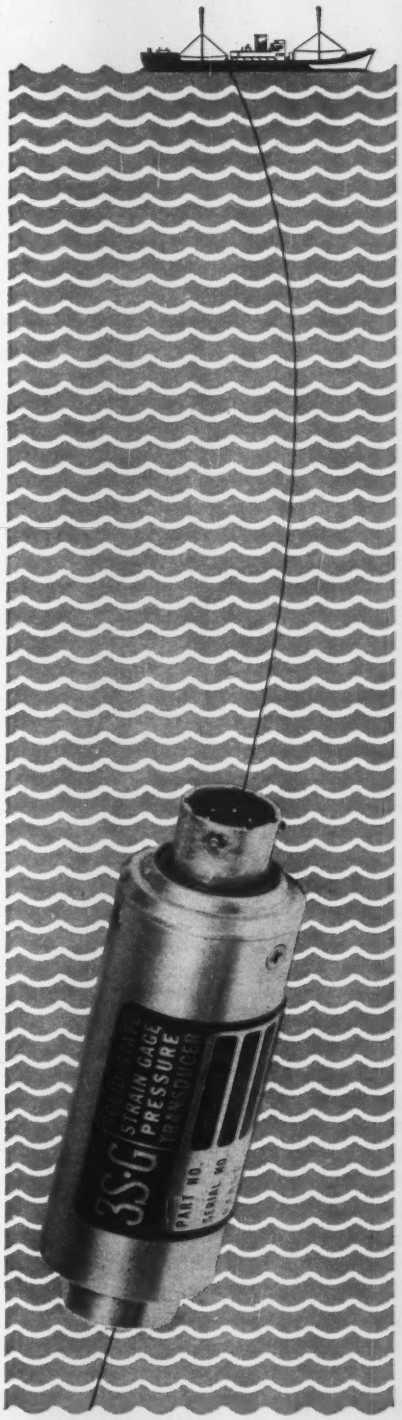


New Type 202 Precision Vector Analyzer features accuracy better than 0.02° or 2%, resolution of 0.005° deviations, full-scale sensitivity of 1° or 0.01 volt rms, and frequency range 20 cps to 40 kc. Essentially a vector computer capable of measuring vector relations between two alternating voltages. Phase angle range is 0-1, 0-2, 0-4, 0-10, 0-20, and 0-180 degrees. *Ad-Yu Electronics Lab., Inc.*, 249-259 *Terhune Ave., Passaic, N. J.*

CIRCLE 331 ON READER-SERVICE CARD

LONG LINES NEED STRONG SIGNALS

THE 3S-G SILICON SEMICONDUCTOR STRAIN-GAGE PRESSURE TRANSDUCER

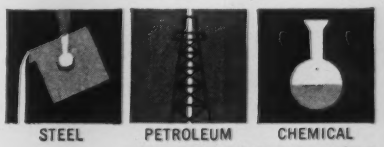


Has a Signal Output of 5 v. d. c.

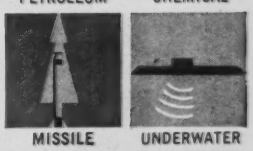
For remote pressure measurement via long lines—under water or above ground—you need a transducer that delivers a high-output signal without additional amplification. The only answer is the new Fairchild 3S-G. It has a 5 v. d.c. output. And it uses semiconductor materials with piezoresistive characteristics as a sensing element.

Extraordinarily accurate (±.003%/degree F error band is not uncommon) in the roughest environment, the tough 3S-G has infinite resolution, self-contained calibration, temperature compensation, and unexcelled repeatability. It is also available with low output (5mv. to 5 v. d.c.), low-pressure gage and absolute (0-10 to 0-100 p.s.i.), high-pressure gage and absolute (0-100 to 0-10,000 p.s.i.), and high-line low-differential (±10 to ±10,000 p.s.i.d.). All versions operate from —65° to 250°F in practically all gaseous and liquid media, including liquid oxygen, strong alkalies, corrosive acids, and high-energy fuels. All are designed to replace strain-gage pressure transducers now being used by industry and the military.

For more information about the 3S-G silicon-semiconductor strain-gage pressure transducer, write Dept. 51 ICS.



wide application in control systems for defense & industry



FAIRCHILD CONTROLS CORPORATION

a Subsidiary of Fairchild Camera & Instrument Corporation

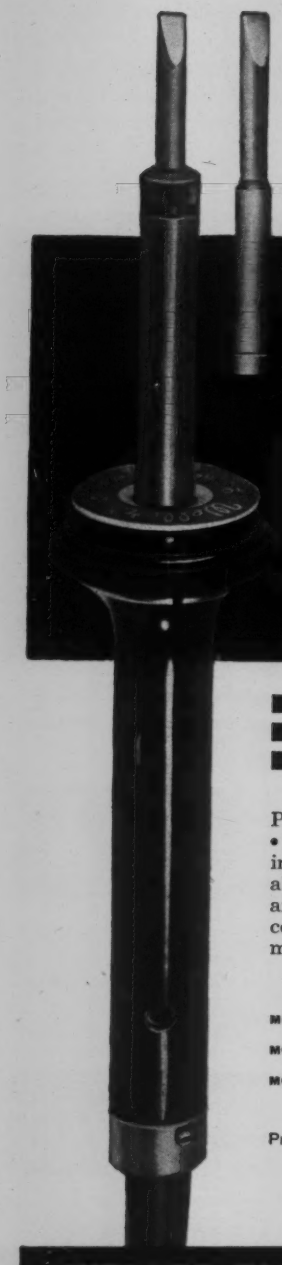
225 PARK AVE., HICKSVILLE, L. I., NEW YORK
6111 E. WASHINGTON BLVD., LOS ANGELES, CAL.

ANOTHER FINE PRODUCT OF FAIRCHILD RESEARCH

CIRCLE 124 ON READER-SERVICE CARD

SIMPLY INTERCHANGE TIPS FOR

3 SOLDERING TEMPERATURES



Magnastat tips are available in 3 different temperature ranges: 750°F., 700°F. and 600°F. controlled to ±3% approximate variance. Merely interchange the tip for the soldering temperature best suited for the job. Over 40 standard tip styles available in 3 temperature ranges.

Weller®

MAGNASTAT®

CONTROLLED TEMPERATURE SOLDERING IRONS

- Automatically maintain correct soldering temperature
- Weigh only half as much as uncontrolled irons
- Give greater heat efficiency with lower wattage

Plus these advanced features for greater efficiency: • Various tip types now available • New tip retaining nut minimizes freezing • New rubber shock absorber prevents sliding • New, rugged, non-arcing snap switch • Handle stays cool • New cord connection locks cord securely in place, yet permits easy replacement • 2 or 3-wire cords available.

3 MAGNASTAT SOLDERING IRONS ARE AVAILABLE

MODEL TC-552. 55 watts, for heat-sensitive soldering $9.00 list

MODEL TC-602. 75 watts, for light to medium soldering $10.00 list

MODEL TC-1202. 120 watts, for medium to heavy soldering..... $11.50 list

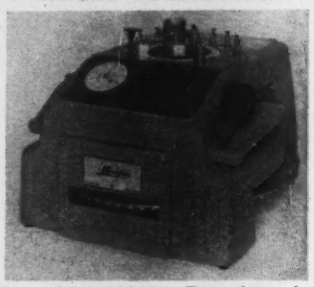
Prices shown are for Magnastat Iron with tip and 2 wire cord.

Send for NEW literature on Weller MAGNASTAT Soldering Irons.

WELLER ELECTRIC CORP. 601 Stone's Crossing Rd. Easton, Pa.

CIRCLE 125 ON READER-SERVICE CARD

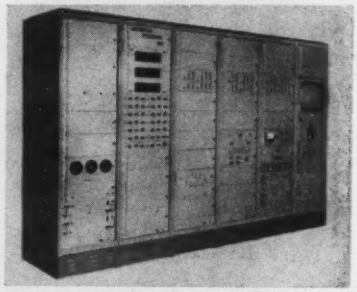
ANGLE POSITIONER



New CO56402004 Precise Angle Positioner positions rotary components. Features high accuracy (±3 sec without coupling attachments), repeatability of 3 sec, readability of 5 sec (2½ seconds by interpolation), dial readout range of ±2½°.—*Kearfott Div., General Precision, Inc.*, 1150 *McBride Ave., Little Falls, N. J.*

CIRCLE 332 ON READER-SERVICE CARD

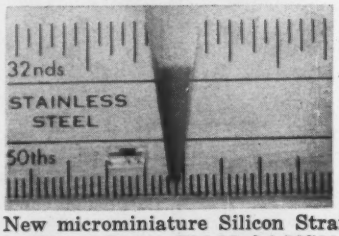
DIGITAL DATA SYSTEMS



New line of standard Series 7000 Digital Data Recording and Alarm Scanning Systems utilizes building-block technique. Scan variables from thermocouples resistance temperature detectors, flowmeters, pneumatic instruments or other transducers at speeds from typewriter readout devices to speeds of presently available magnetic tape recording units. Systems with accuracies to 0.01% are available.—*Monitor Systems, Inc., Subs. of Epsco, Inc., Dept.* 19, *Fort Washington Industrial Park, Fort Washington, Pa.*

CIRCLE 333 ON READER-SERVICE CARD

SEMICONDUCTOR STRAIN GAGE



New microminiature Silicon Strain Gage Micro-Sensor TM Model MS301-120, of only 0.05" active length, has gage factor of 110 and resistance of 120 ohms. Said to be approximately 65 times more sensitive than similar metallic devices.—*Micro Systems, Inc., Subs. of Electro-Optical Systems, Inc.*, 319 *Agostino Rd., San Gabriel, Calif.*

CIRCLE 334 ON READER-SERVICE CARD

CONDUCTIVITY METER

New Solu Meter can measure conductivities ranging from distilled and demineralized water to concentrated acids and bases. Output terminals are for connection to a standard millivolt recorder or controller. Portable or panel mounted.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, Essex Co., N. J.*

CIRCLE 335 ON READER-SERVICE CARD

STATISTICAL SHOCK RECORDER

New unidirectional, four-channel Statistical Shock Recorder Model 3R-4 features accuracy of ±5%, frequency response 0-4 cps (min.), no power requirements. Conforms to MIL E-5272. —*Inertia Switch Inc., 311 W. 43rd St., New York 36, N. Y.*

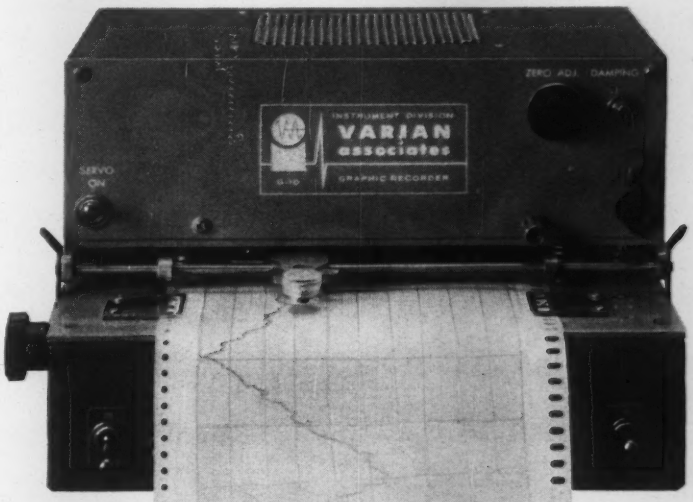
CIRCLE 336 ON READER-SERVICE CARD

DC CURRENT SUPPLY

New Evenvolt D-C Current Supply for precision potentiometers replaces wet and dry batteries. Available for voltages up to 6.0 vdc at a maximum current of 25.0 ma. A-c line voltage is reduced and isolated by transformer and rectified by silicon diodes. D-c voltage is regulated by 2-stage Zener-diode and bridge circuit to give the output regulation.—*InstruLab, Inc., 1205 Lamar St., Dayton 4, Ohio.*

CIRCLE 337 ON READER-SERVICE CARD

Why Varian's G-10 Potentiometer Recorder is the



PRACTICAL RECORDING CHOICE

This recorder has gained an enviable reputation over the years for performing reliably in every recording chore within its capabilities. It owes nothing to styling but the dictates of practicality and delivers performance to match — 10 to 100 mv d.c. full scale; sixteen chart speeds from 1"/hr. to 16"/min.; 1% accuracy and ¼%-of-span sensitivity; 1 or 2½ second full scale balance time; economical 5" charts with a flat platen for easy note-making. Prices — from $385.00. Fast delivery; parts and service — world-wide.

Consider the rightness of the G-10 — a potentiometer recorder that has stood the test of time, use and acceptance.

For details, write Instrument Division:

VARIAN associates

PALO ALTO 27, CALIFORNIA

NMR & EPR SPECTROMETERS, MAGNETS, FLUXMETERS, GRAPHIC RECORDERS, MAGNETOMETERS, MICROWAVE TUBES, MICROWAVE SYSTEM COMPONENTS, HIGH VACUUM EQUIPMENT, LINEAR ACCELERATORS, RESEARCH AND DEVELOPMENT SERVICES

CIRCLE 126 ON READER-SERVICE CARD

WITH SO MANY OTHERS ON THE MARKET, WHY HAS BROOKS BROUGHT OUT A NEW LINE OF LEVEL TRANSMITTERS? Because no level control instrument now available can quite match (or even come close) to our new Series MPT level transmitters in overall capability. Brash claim? Not at all. Here, see for yourself: **1.** Independent transmission and indication, either pneumatic or electric, with optional alarm signaling and/or on-off control – all in a single instrument. **2.** Operation from either buoyant or displacer floats, with a buoyant-float range of 0-24 inches (nearly five times that of any other directly-actuated level transmitter). **3.** Linear or characterized output – can be square root or other exponential function. (MPT units can give a linear output from Parshall flumes and V-notch weirs.) **4.** High-pressure capability –standard models are rated at 1500 psi, can be made for working pressures to 50,000 psi. **5.** Adaptability – suitable for use with float mounted either within the vessel or in an external cage. **6.** Available in a practically unlimited range of wetted-parts materials for corrosive services.

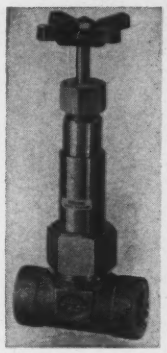
Write for Bulletin 830

BROOKS INSTRUMENT COMPANY, INC.
5008 W. Vine Street, Hatfield, Pa.

SA-2326

CIRCLE 127 ON READER-SERVICE CARD

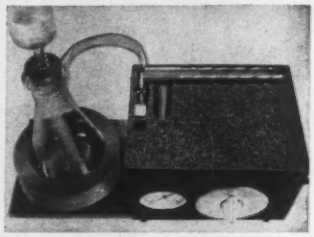
BELLOWS SEAL VALVES



New 473-Series bellows-seal Valves have forged stainless steel bodies with inert arc welded bellows assemblies. Standard valves are for high vacuum and cryogenic systems. Model HY473 (high-pressure version) is rated 2000 psi and 600°F, Model LY 473 (low-pressure version) is rated 400 psi, up to 350°F, and has replaceable Teflon seats and gaskets.—*Hoke Inc., 1 Tenakill Park, Cresskill, N. J.*

CIRCLE 338 ON READER-SERVICE CARD

AIR CONTAMINATION SAMPLER



New Contamination Sampler measures amount of dust or other foreign material on a filter surface expressed in number of particles per cu ft of air. Consists of a Millipore open-face monitor with a filter on the surface, electrical air pump, glass flask, and timer with automatic shut-off.—*Standard Valve Div., Hydraulic Research and Mfg. Co., Div. of Bell Aerospace Corp., 2835 N. Naomi St., Burbank, Calif.*

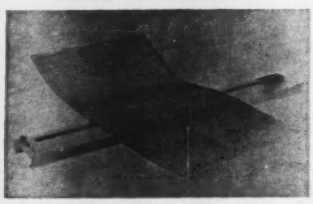
CIRCLE 339 ON READER-SERVICE CARD

WELDED DIAPHRAGM SEALS

New welded Diaphragm Seals feature machined shape which reduces the internal volume for a minimum of temperature error. Shape is also backstop in case of instrument leakage. All seals are clean-out type.—*Mansfield & Green, Inc., 6185 Cochran Rd., Cleveland 39, Ohio.*

CIRCLE 498 ON READER-SERVICE CARD

EDGE INSPECTOR



New Webalarm for fabric, paper, or plastic film inspection signals audibly or visually when width of moving webb falls outside preset tolerances, unaffected by sideslip or speed variation of moving material.—*Matrix Controls Co., Inc., Box 22, Somerville, N. J.*

CIRCLE 340 ON READER-SERVICE CARD

FOR MORE PRODUCT DATA

CIRCLE THE NUMBER that corresponds to the number appearing with the product reported or advertised in this issue.

PRINT YOUR NAME, title, company, address, etc., clearly, detach and mail. No postage needed.

Every month—thousands of readers turn to and use Instruments and Control Systems' ANNUAL BUYERS' GUIDE to help decide specs and procurement of instrumentation and control equipment, systems, and components.

Plan now to ADVERTISE in the next edition—October 1961. Contact our nearest representative—see list on page 1336, this issue.

FIRST CLASS
PERMIT NO. 1441
PITTSBURGH, PA.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY—

INSTRUMENTS and CONTROL SYSTEMS
Instruments Publishing Co., Inc.)
845 Ridge Avenue
Pittsburgh 12, Pa.

8/61

Valid only; In U.S., Canada and Mexico; If filled out completely; Until 11-1-61 August 61

Name ..... Title .....

Company ..... Address .....

City ..... Zone ..... State .....

Principal Product of Your Plant .....

☐ Check for address change. Show OLD address here: .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	321	341	361	381	401	421	441	461	481
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	322	342	362	382	402	422	442	462	482
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	323	343	363	383	403	423	443	463	483
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	324	344	364	384	404	424	444	464	484
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	325	345	365	385	405	425	445	465	485
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	326	346	366	386	406	426	446	466	486
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	327	347	367	387	407	427	447	467	487
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	328	348	368	388	408	428	448	468	488
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	329	349	369	389	409	429	449	469	489
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	330	350	370	390	410	430	450	470	490
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	331	351	371	391	411	431	451	471	491
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	332	352	372	392	412	432	452	472	492
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	333	353	373	393	413	433	453	473	493
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	334	354	374	394	414	434	454	474	494
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	335	355	375	395	415	435	455	475	495
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296	316	336	356	376	396	416	436	456	476	496
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297	317	337	357	377	397	417	437	457	477	497
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298	318	338	358	378	398	418	438	458	478	498
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339	359	379	399	419	439	459	479	499
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500

PRODUCT INDEX

The following is a handy reference to products (and their reader-service number) advertised in this issue. For more information on any product mentioned, circle the corresponding number on the reader-service card.

This index is published as a service. Every care is taken to make it accurate, but I&CS assumes no responsibility for errors or omissions.

Accelerometer, 100
Air Dryer, Filter, 117
Amplifier, 119
An/Dig Converter, 129
Annunciator, 68, 74, 199
Anti Static, 44
Battery, 18
Beam Compass, 190
Bolometer Mount, 86
Bridge, 86, 151
Calibration Standard, 3, 42, 85, 86
Camera, 8
Capacitance Monitor, 39
Chart, 145
Chart Drive, 33, 41
Circuit Tester, 62
Computer, Analog, 43, 88, 89, 90
Computer, Digital, 3
Conductivity, 134
Controller, 60
Counter, 4, 84, 102, 113
Current Regulator, 32
Data Logger, 23
Densitometer, 94
Digital Module, 131
Digital Readout, 91
Digital Voltmeter, 49, 200
Drill, 45
Ducts/Raceways, 167
Engraver, 144
Feeder, 11
Flowmeter, 67, 98, 110, 114, 127
Galvanometer, 101
Gas Density, 139
Glass Tubes, 132
Hardness, 136
Humidity, 148
Hydrocarbon Detector, 137
Insulation Test, 47, 135
Integrator, 179, 194
Inverter, 70
I-fra Red, 154
IR Spectroscopy, 58
Jacks, 138
Jewel Assembly, 197
Leak Detector, 104
Lens, 175
Level, 9, 27, 28, 29, 67, 127, 141, 160, 174
Magnetic Tape, 16
Memory, 64
Meter-Relay, 142
Microscope, Stereo, 21
Numerical Control, 40
Optics, 48, 154, 175
Outlets, 155
Oxygen Analyzer, 7
Panel Meter, 92, 142
Permanent Magnet, 52
pH, 34, 66, 140
Photoelectric Control, 4, 198
Pneumatic Transmitter, 34
Potentiometer, 42, 85
Power Supply, 70, 95, 115, 164, 173, 177
Power Supply, HV, 177
Pressure Control, 35, 166
Pressure Differential, 12, 98
Pressure Gage, 10, 12, 37, 105, 152, 153, 182
Pressure Regulator, 13, 55, 118, 148, 212
Pressure Switch, 72, 73
Pressure Transducer, 5, 6, 103, 119, 172
Printer, 79
Process Computer, 24
Process Control, 81
Pulse Integrator, 111
Punch Tape, 17
Pyrometer, 116
Radioactivity, 160
Rebuilt Instruments, 195
Recorder, 8, 22, 25, 30, 44, 60, 63, 96, 97, 103, 107, 126, 201
Recorder, Event, 30
Rectifier, 177
Res. Temp. Detector, 2
Rheostat, 196
Servo Amplifier, 93
Shift Register, 131
Soldering, 125
Specific Gravity, 120, 160
Speed Switch, 53
Strain Gage, 99, 124
Stream Analyzer, 14, 65
Switch, 19
Tachometers, 150, 189, 192
Telemeter, 46, 57, 120, 121, 122, 157, 161
Temperature Control, 77, 80, 116, 128, 142, 148, 211
Temp. Meter, 116, 151, 182
Temp. Reference, 163
Temp. Sens. Paint, 38, 97
Temp. Transducer, 2
Thermocouple, 71, 76, 123, 138, 165, 211
Thermometer, 162, 182
Thermostat, 191
Time Delay Relay, 32
Tube Fitting, 31, 61, 82
Tubing, 54, 61, 71, 147, 181
Vacuum, 5, 188
Valve, 13, 143
Valve, Ball, 36, 109
Valve, Control, 15, 26, 51, 75, 78, 83
Valve, Needle, 146
Valve, Relief, 69, 169
Valve, Servo, 1
Valve, Small, 73
Valve, Solenoid, 20, 87
Voltage Reference, 133, 180
Voltmeter, 49, 200
Wire Stripper, 50, 193

Make certain you get your own copy of

INSTRUMENTS & CONTROL SYSTEMS

each month by filling out and sending in the subscription card facing page 1489.

Valid only; in U.S., Canada and Mexico; if filled out completely; Until 11-1-61 **August 61**

Name ..... Title .....

Company ..... Address .....

City ..... Zone ..... State .....

Principal Product of Your Plant .....

☐ Check for address change. Show OLD address here: .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	321	341	361	381	401	421	441	461	481
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	322	342	362	382	402	422	442	462	482
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	323	343	363	383	403	423	443	463	483
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	324	344	364	384	404	424	444	464	484
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	325	345	365	385	405	425	445	465	485
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	326	346	366	386	406	426	446	466	486
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	327	347	367	387	407	427	447	467	487
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	328	348	368	388	408	428	448	468	488
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	329	349	369	389	409	429	449	469	489
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	330	350	370	390	410	430	450	470	490
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	331	351	371	391	411	431	451	471	491
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	332	352	372	392	412	432	452	472	492
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	333	353	373	393	413	433	453	473	493
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	334	354	374	394	414	434	454	474	494
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	335	355	375	395	415	435	455	475	495
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296	316	336	356	376	396	416	436	456	476	496
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297	317	337	357	377	397	417	437	457	477	497
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298	318	338	358	378	398	418	438	458	478	498
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339	359	379	399	419	439	459	479	499
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500

BUSINESS REPLY MAIL

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY—

INSTRUMENTS and CONTROL SYSTEMS

Instruments Publishing Co., Inc.)

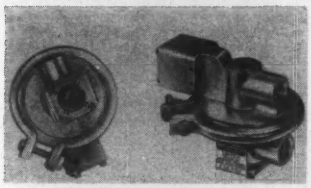
845 Ridge Avenue

Pittsburgh 12, Pa.

FIRST CLASS PERMIT NO. 1441 PITTSBURGH, PA.

8/61

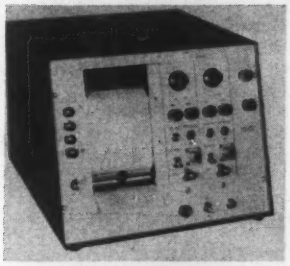
SENSITIVE SWITCHES



New Deltadyne electrical Switches which signal pressures and differential pressures in the low range of 0.25" to 16" WC contain no mechanical linkages and are over-pressure rated 250 psi and for frequencies up to 2000 cps.—*Pall Corp., Glen Cove, N. Y.*

CIRCLE 341 ON READER-SERVICE CARD

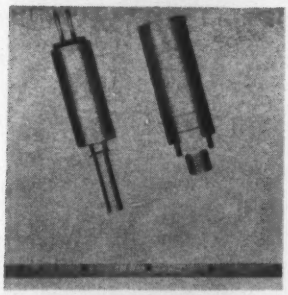
OSCILLOGRAPH



New self-contained dual-channel Direct Writing Oscillograph with sealed inking system features variety of interchangeable plug-in preamplifiers (low and medium gain, chopper-stabilized, carrier, and others) with measurement range from 0.0001 to 400 v and frequency response from dc to 100 cps, choice of ink or inkless traces on 40-mm charts, curvilinear or rectangular, chart speeds 1, 5, 25, and 100mm/sec with push button selection.—*Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio.*

CIRCLE 342 ON READER-SERVICE CARD

PRESSURE TRANSDUCERS



Two new lines of miniaturized differential transformer Pressure Transducers, Model "P" with pressure sensing diaphragm at its end, and miniaturized Model "L" with the diaphragm within the body, employ a differential transformer design which is sensitive to diaphragm movements of less than 0.005". The transformer is fed a 0.5-to-10 v, 10-kc signal. Output accuracy is 0.5% overall.—*Precision Research Inc., Box 434, Stamford, Conn.*

CIRCLE 343 ON READER-SERVICE CARD

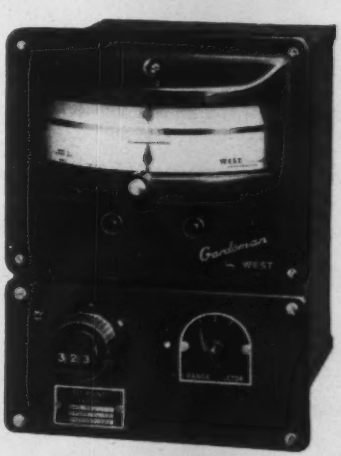
DIAL IN ON GREATER TEMPERATURE CONTROL ACCURACY!

"Pin-point" accuracy is at your fingertips with West's new tubeless, solid-state digital set point controllers. By adjusting the 3-digit, 1000-unit dial, the control point can be set in increments (depending on range) as small as ½°. Null balance circuit provides exceptional sensitivity . . . closer than ¼° with most thermocouples.

Calibration is not affected by leadwire length. Continuous cold junction compensation is provided electrically. Repeatability, linearity and resolution are excellent.

These compact units may be panel or surface-mounted. Available in on-off, proportioning and stepless (saturable core reactor) control modes . . . one, two or three ranges can be provided. For full details, write for Bulletin JY.

NEW DIGITAL SET POINT CONTROLLERS ...by WEST

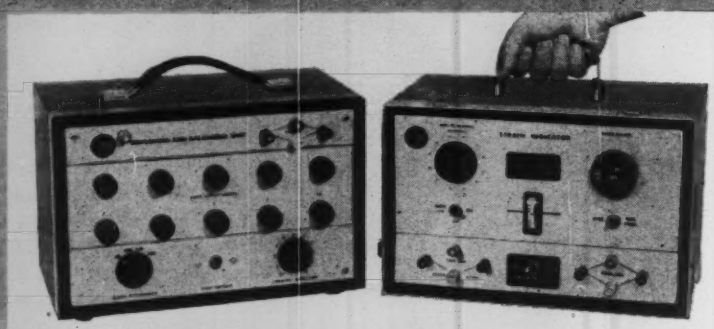


WEST Instrument CORPORATION
SALES OFFICES IN PRINCIPAL CITIES
FACTORY AND GENERAL OFFICES
4355 W. MONTROSE, CHICAGO 41, ILL.
BRITISH SUBSIDIARY
WEST INSTRUMENT, LTD.
52 Regent St., Brighton 1, Sussex

CIRCLE 128 ON READER-SERVICE CARD

NEW...

BLH-BUILT STRAIN INSTRUMENTS ARE EASIER TO READ, SIMPLER TO OPERATE



BLH announces new instrumentation policy. New instruments marketed by the world leader in strain and force measurement will now be designed and built entirely by instrument specialists in the modern BLH facility in Waltham, Mass. This policy will provide improved instruments with single-source responsibility and more favorable pricing.

Digital strain indicator sets a new standard for ease of operation and readout. It features digital readout to eliminate interpolation from dials and meters, wider gage factor (1.50–4.50) and gage resistance range (60–2000 ohms), battery or ac operation, and accuracy within 0.1% of reading or 5 microinches/inch. This portable unit is transistorized, weighs only 18 lb., has a durable Formica case, and is low in cost.

Switching and balancing unit, for use with any BLH strain indicator, permits readings to be taken on each of a group of gages. Speeds up test work where time is an important factor because of ambient temperature variations, creep, inherent characteristics of the test material, or limited availability of test facilities. Units can be stacked to handle gages or gage configurations in multiples of 10. Simplified gage connection board. Special friction drive zero adjustments require no locking.

Improved repeatability—better than 1 microinch/inch for a half-million channel selector switch rotations. Long-life Formica case.

Local availability through BLH sales engineering representatives in the U.S. and Canada. See the one nearest you or write direct for data sheets.

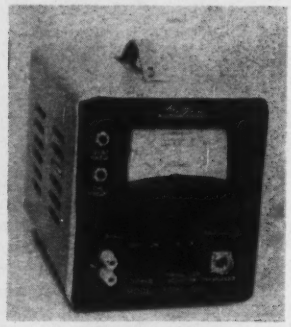
BALDWIN • LIMA • HAMILTON
Electronics & Instrumentation Division
Waltham 54, Mass.

FIRST in force measurement

SR-4® Strain Gages • Transducers • Temperature Sensors • Systems

CIRCLE 99 ON READER-SERVICE CARD

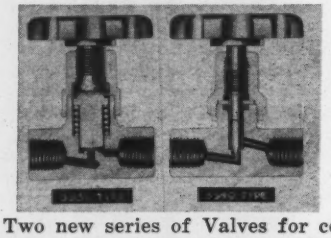
BRIDGE CONTROL READOUT



New portable, solid-state Bridge Control Readout BCR1-0, is a combined power supply, bridge balance and electrical readout meter for any two- or four-arm strain gage, such as pressure transducers or load cells. No additional resistors are required, and proper power source and amplification are self-contained. Gain stability is ±0.5% over 8 hours, after 15-minute warm-up. Non-linearity and hysteresis: less than ±0.5% of full scale.—*Statham Instruments, Inc.*, 12401 *W. Olympic Blvd., Los Angeles* 64, *Calif.*

CIRCLE 344 ON READER-SERVICE CARD

INSTRUMENT VALVES



Two new series of Valves for corrosive gas instrumentation control and similiar processing lines include Type 5939 which features a positive metallic diaphragm seal and Type 5940, a metering valve with stem threads isolated from the line contents by Teflon packing. Made in brass, 303 s.s., and aluminum-silicon bronze.—*Superior Valve & Fittings Co.*, 1509 *W. Liberty Ave., Pittsburgh* 22, *Pa.*

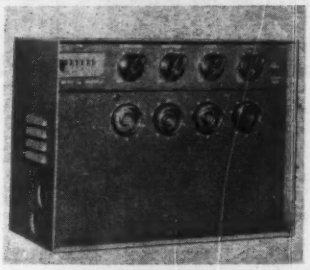
CIRCLE 345 ON READER-SERVICE CARD

DIGITAL RECORDING SYSTEM

New Model 1150R Digital Recording System for converting analog voltages, in the range of 0 to 9.9 v, to a two-digit, binary decimal code available from parallel outputs, or as serial information which is in the form of NRZI Serial format, is completely self-checking, with indicators and test push buttons to activate all internal functions.—*Navigation Computer Corp., Valley Forge Industrial Park, Norristown, Pa.*

CIRCLE 346 ON READER-SERVICE CARD

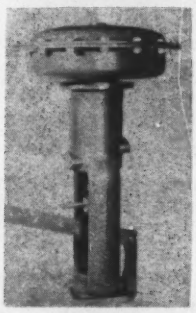
PREDETERMINING COUNTER



New Predetermined Electronic Counter, Tally Count® Model TC-850, in 1-, 2-, 3-, or 4-digit models, operates from any external circuit, from photo-electric or magnetic-impulse amplifiers and pickups, linear footage measurement wheels, etc. Maximum counting rate of standard model is 3000/min.—*Standard Instrument Corp., 657 Broadway, New York 12, N. Y.*

CIRCLE 347 ON READER-SERVICE CARD

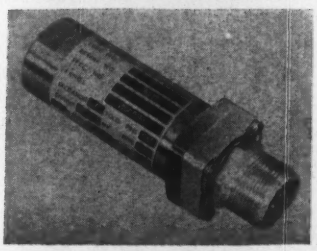
DAMPER MOTOR



New Type 658U diaphragm actuated Lever Operator for dampers, switches, governors, etc. has either direct or reverse acting lever. Bulletin Page E-77.—*Fisher Governor Co., Box 307, Marshalltown, Iowa.*

CIRCLE 348 ON READER-SERVICE CARD

PRESSURE TRANSDUCER

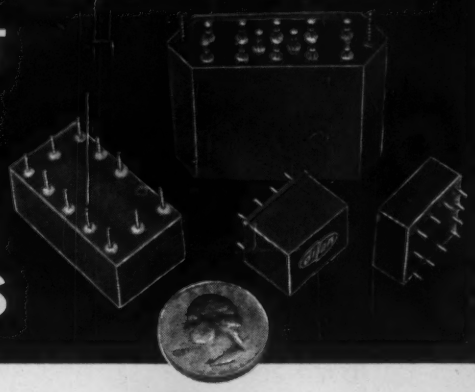


New Pressure Transducer, Type 4-350, features an over-pressure capability of 10 times rated range, high sensitivity of 50 mv, low residual unbalance, a combined figure of ±0.35% for linearity and hysteresis, repeatability within +0.10% FR. Utilities unbonded strain gage principle with a four-active-arm spring-type sensing element and a diaphragm force summing area.—*Consolidated Electrodynamics Corp., Subs. of Bell & Howell 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 349 ON READER-SERVICE CARD

1-WAY OR 2-WAY

THE MOST RELIABLE SHIFT REGISTER ELEMENTS



Magnetic-core shift registers are the most reliable kind. Best of the magnetic breed is the exclusive DI-AN core-transistor circuit, in which the transistor is used only as a non-critical switch, creating high 1:0 ratios, drawing but flea-power, tolerating wide variations in voltage, temperature, signal. Encapsulated, economical, practically eternal.

Newest achievement is our **two-way** element. Shifts right **and** left, up **and** down, reads out non-destructively, creates additional degrees of freedom in data organization.

Write — we'll send thousands of words on DI-AN shift-register products.

di an®

DI/AN CONTROLS, INC.

944 Dorchester Avenue • Boston 25, Mass. • Avenue 8-7700

magnetic digital/analog systems and components

CIRCLE 131 ON READER-SERVICE CARD

GLASS CYLINDERS
RODS • TUBES
CIRCLES & SPECIAL SHAPES

•

Experimental and Production Blowing
Your Inquiries Invited.

FABRICATED and CUT to Your SPECIFICATIONS

Glass Tubes and Rods for Scientific Use—Lamps, Furniture, Lighting & Decorative Fixtures—Display Domes—Contact Cutters of Tube and Rod.

CRYSTAL GLASS TUBE & CYLINDER CO.

7318 South Chicago Ave. • Chicago 19, Ill.

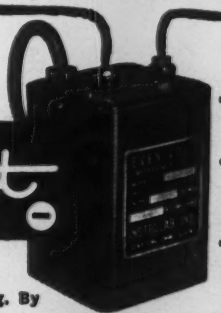
CIRCLE 132 ON READER-SERVICE CARD

INSTRULAB'S

Temperature Compensated

evenvolt

⊕ Constant Voltage Unit ⊖



Replaces Batteries and All Standardizing Components Including Standard Cell In

POTENTIOMETERS

• CONTROLLERS • INDICATORS • RECORDERS

Mfg. By *INSTRULAB, INC.*

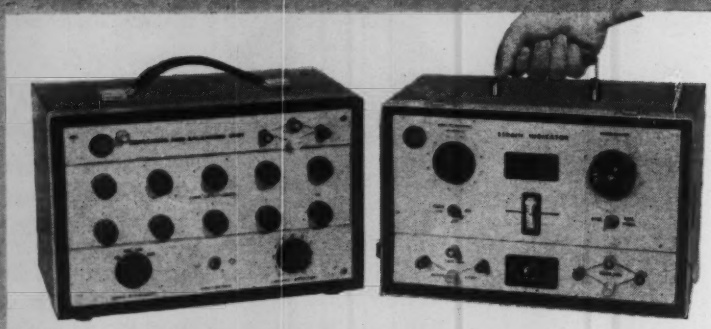
1205 Lamar Street
Dayton 4, Ohio
Phone BA 3-2241

Outstanding FEATURES

- Eliminates batteries ...errors due to battery exhaustion
- Reliable construction...from quality components, long, trouble-free service
- A Precise voltage regulator . . . max. ±.04% for ±20% voltage variation
- Quickly Installed... Fits present instrument battery space.
- No Tubes to replace

CIRCLE 133 ON READER-SERVICE CARD

NEW...
BLH-BUILT STRAIN INSTRUMENTS ARE EASIER TO READ, SIMPLER TO OPERATE



BLH announces new instrumentation policy. New instruments marketed by the world leader in strain and force measurement will now be designed and built entirely by instrument specialists in the modern BLH facility in Waltham, Mass. This policy will provide improved instruments with single-source responsibility and more favorable pricing.

Digital strain indicator sets a new standard for ease of operation and readout. It features digital readout to eliminate interpolation from dials and meters, wider gage factor (1.50–4.50) and gage resistance range (60–2000 ohms), battery or ac operation, and accuracy within 0.1% of reading or 5 microinches/inch. This portable unit is transistorized, weighs only 18 lb., has a durable Formica case, and is low in cost.

Switching and balancing unit, for use with any BLH strain indicator, permits readings to be taken on each of a group of gages. Speeds up test work where time is an important factor because of ambient temperature variations, creep, inherent characteristics of the test material, or limited availability of test facilities. Units can be stacked to handle gages or gage configurations in multiples of 10. Simplified gage connection board. Special friction drive zero adjustments require no locking.

Improved repeatability—better than 1 microinch/inch for a half-million channel selector switch rotations. Long-life Formica case.

Local availability through BLH sales engineering representatives in the U.S. and Canada. See the one nearest you or write direct for data sheets.

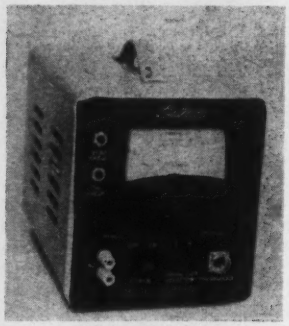
BALDWIN • LIMA • HAMILTON
Electronics & Instrumentation Division
Waltham 54, Mass.

FIRST in force measurement

SR-4® Strain Gages • Transducers • Temperature Sensors • Systems

CIRCLE 99 ON READER-SERVICE CARD

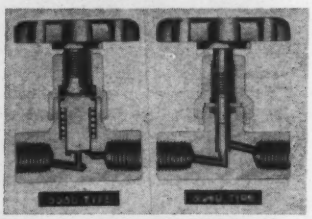
BRIDGE CONTROL READOUT



New portable, solid-state Bridge Control Readout BCR1-0, is a combined power supply, bridge balance and electrical readout meter for any two- or four-arm strain gage, such as pressure transducers or load cells. No additional resistors are required, and proper power source and amplification are self-contained. Gain stability is ±0.5% over 8 hours, after 15-minute warm-up. Non-linearity and hysteresis: less than ±0.5% of full scale.—*Statham Instruments, Inc.*, 12401 *W. Olympic Blvd., Los Angeles 64, Calif.*

CIRCLE 344 ON READER-SERVICE CARD

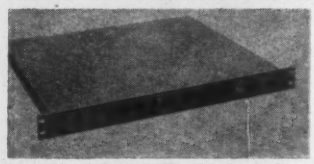
INSTRUMENT VALVES



Two new series of Valves for corrosive gas instrumentation control and similiar processing lines include Type 5939 which features a positive metallic diaphragm seal and Type 5940, a metering valve with stem threads isolated from the line contents by Teflon packing. Made in brass, 303 s.s., and aluminum-silicon bronze.—*Superior Valve & Fittings Co.*, 1509 *W. Liberty Ave., Pittsburgh 22, Pa.*

CIRCLE 345 ON READER-SERVICE CARD

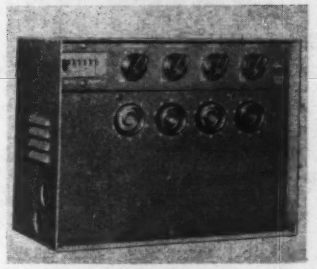
DIGITAL RECORDING SYSTEM



New Model 1150R Digital Recording System for converting analog voltages, in the range of 0 to 9.9 v, to a two-digit, binary decimal code available from parallel outputs, or as serial information which is in the form of NRZI Serial format, is completely self-checking, with indicators and test push buttons to activate all internal functions.—*Navigation Computer Corp., Valley Forge Industrial Park, Norristown, Pa.*

CIRCLE 346 ON READER-SERVICE CARD

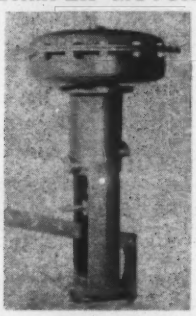
PREDETERMINING COUNTER



New Predetermined Electronic Counter, Tally Count® Model TC-850, in 1-, 2-, 3-, or 4-digit models, operates from any external circuit, from photo-electric or magnetic-impulse amplifiers and pickups, linear footage measurement wheels, etc. Maximum counting rate of standard model is 3000/min.—*Standard Instrument Corp., 657 Broadway, New York 12, N. Y.*

CIRCLE 347 ON READER-SERVICE CARD

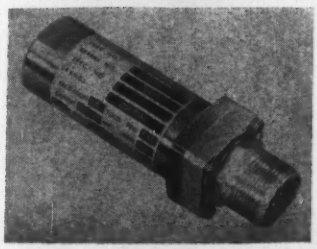
DAMPER MOTOR



New Type 658U diaphragm actuated Lever Operator for dampers, switches, governors, etc. has either direct or reverse acting lever. Bulletin Page E-77.—*Fisher Governor Co., Box 307, Marshalltown, Iowa.*

CIRCLE 348 ON READER-SERVICE CARD

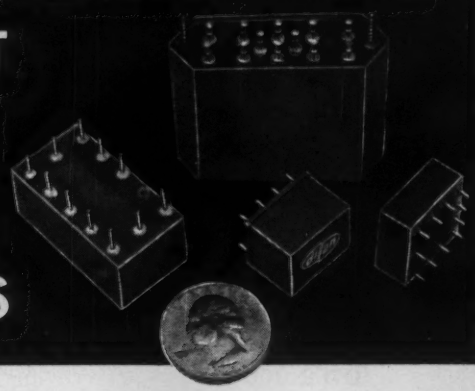
PRESSURE TRANSDUCER



New Pressure Transducer, Type 4-350, features an over-pressure capability of 10 times rated range, high sensitivity of 50 mv, low residual unbalance, a combined figure of ±0.35% for linearity and hysteresis, repeatability within +0.10% FR. Utilities unbonded strain gage principle with a four-active-arm spring-type sensing element and a diaphragm force summing area.—*Consolidated Electrodynamics Corp., Subs. of Bell & Howell 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 349 ON READER-SERVICE CARD

1-WAY OR 2-WAY
THE MOST RELIABLE SHIFT REGISTER ELEMENTS



Magnetic-core shift registers are the most reliable kind. Best of the magnetic breed is the exclusive DI-AN core-transistor circuit, in which the transistor is used only as a non-critical switch, creating high 1:0 ratios, drawing but flea-power, tolerating wide variations in voltage, temperature, signal. Encapsulated, economical, practically eternal.

Newest achievement is our **two-way** element. Shifts right **and** left, up **and** down, reads out non-destructively, creates additional degrees of freedom in data organization.

Write — we'll send thousands of words on DI-AN shift-register products.

di an® **DI/AN CONTROLS, INC.**
944 Dorchester Avenue • Boston 25, Mass. • Avenue 8-7700
magnetic digital/analog systems and components

CIRCLE 131 ON READER-SERVICE CARD

GLASS CYLINDERS
RODS • TUBES
CIRCLES & SPECIAL SHAPES
•
Experimental and Production Blowing
Your Inquiries Invited.

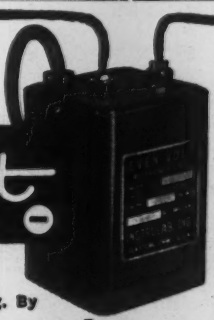
FABRICATED and CUT to Your SPECIFICATIONS

Glass Tubes and Rods for Scientific Use—Lamps, Furniture, Lighting & Decorative Fixtures—Display Domes—Contact Cutters of Tube and Rod.

CRYSTAL GLASS TUBE & CYLINDER CO.
7318 South Chicago Ave. • Chicago 19, Ill.

CIRCLE 132 ON READER-SERVICE CARD

INSTRULAB'S
Temperature Compensated
evenvolt
⊕ Constant Voltage Unit ⊖



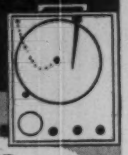
Replaces Batteries and All Standardizing Components Including Standard Cell In
POTENTIOMETERS
• CONTROLLERS • INDICATORS • RECORDERS

Mfg. By **INSTRULAB, INC.**
1205 Lamar Street
Dayton 4, Ohio
Phone BA 3-2241

Outstanding FEATURES
- **Eliminates batteries** ...errors due to battery exhaustion
- **Reliable construction**...from quality components, long, trouble-free service
- **A Precise voltage regulator** . . . max. ±.04% for ±20% voltage variation
- **Quickly Installed**... Fits present instrument battery space.
- **No Tubes to replace**

CIRCLE 133 ON READER-SERVICE CARD

Industrial Instruments Inc.
covers
THE WHOLE FIELD OF SOLUTION CONDUCTIVITY



from ULTRA PURE WATER to FUMING SULFURIC ACID

from REFRIGERANT BRINES to OVER 300°F

from HIGH VACUUM to 7500 PSI

from 1/100 ML SAMPLES to THE PACIFIC OCEAN

from BATTERY to LINE OPERATION

from 1/1000 CELL CONSTANT to OVER 1000/CM

from PLATINUM ELECTRODES to NO ELECTRODES

from D.C. to 20 KC

from SIMPLE LAB METERS to MULTIPOINT RECORDER CONTROLLERS

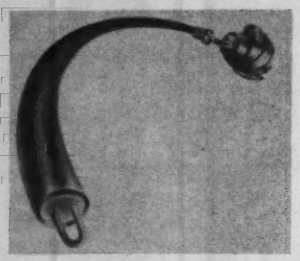
from POLISHED FILTRATES to THICK SLURRIES

Write for complete information on Solu Bridges, Solu Meters, Recorders, Larson-Lane Steam and Condensate Analyzers, Thallium Dissolved Oxygen Analyzers, Conductivity Cells and Accessories.

Industrial Instruments Inc.
89 Commerce Road Cedar Grove, Essex County, N. J.

CIRCLE 134 ON READER-SERVICE CARD

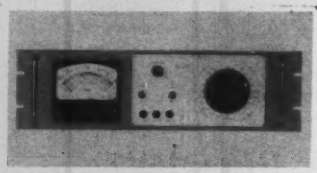
METAL-SHEATED T/C



New Trinox metal-sheated Thermocouples provide long life because wires are surrounded with metallic oxide insulation encased in a corrosion-resistant metallic sheath. Temperature ranges are to 2100° and to 3200°F, utilizing noble metals. Six standard OD's from 5/16" to 0.040". —*Trinity Equipment Corp., Cortland, N. Y.*

CIRCLE 350 ON READER-SERVICE CARD

VOLT-OHM-MILLIAMMETER



New Model 630-NA-RM is a 68-range mirror-scaled Volt-Ohm-Milliammeter featuring high accuracy on the same scale for ac and dc; frequency compensation from 35 cps to 20 kc; temperature compensation.—*Triplett Electrical Instrument Co., Bluffton, Ohio.*

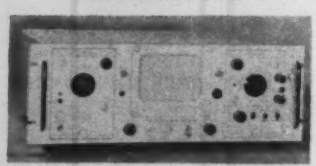
CIRCLE 351 ON READER-SERVICE CARD

THERMISTOR THERMOMETER

New Model 42SL in the transistorized Thermistor Thermometer series covers range from −80° to +40°C in three overlapping steps. Absolute accuracy is ± 0.5°C, readability 0.25°C, and reproducibility is better than readability. Battery powered and portable, 5½" x 4" x 6". Bulletin.—*Yellow Springs Instrument Co., Box 106, Yellow Springs, Ohio.*

CIRCLE 352 ON READER-SERVICE CARD

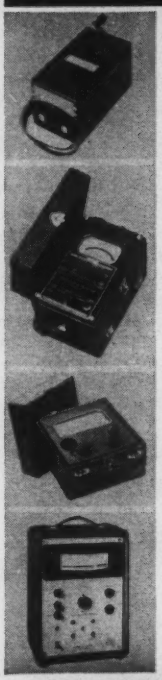
OSCILLOSCOPE



New rack-mount Oscilloscope Type RM561 accepts a wide range of plug-in units in both channels. Characteristics include: a 5" rectangular CRT, 3.5 kv accelerating potential, 8 x 10 cm viewing area, z-axis input, amplitude calibrator, regulated d-c heater voltage, and regulated d-c supply.—*Tektronix, Inc., Box 500, Beaverton, Ore.*

CIRCLE 353 ON READER-SERVICE CARD

MEGOHMER
INSULATION TESTERS



GENERATOR TYPES

MINOR—Dwarf Size
500V, DC, 100 Megohms

MAJOR—Small Size
Constant Voltage 500V
Megohm & Ohm Scales

STANDARD—Heavy Duty
500/1000V DC
up to 2000 Megs.

BATTERY VIBRATOR TYPES

NON-CRANKING

MODEL B-6—0-200 Megs.
2000 Ohms, AC-DC Volts

MODEL B-7—20/200 Megs.
200/20,000 Ohms.

PLUG IN TYPE

MODEL P-1 for PRODUCTION TESTING
115V AC line operated
500/1000V DC
100/1000/2000 Megohms

ELECTRONIC TYPE

20,000,000 Megohms

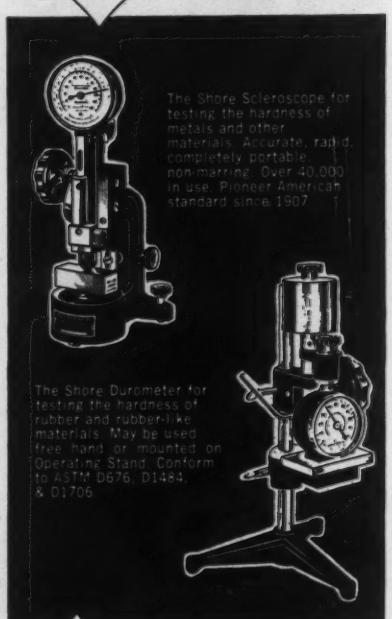
MODEL 29A with 11 ranges
Range 300,000 to 20,000,000 megohms
Test Potentials
85V/500V DC

Booth #213 ISA
Los Angeles

HERMAN H. STICHT CO., INC.
27 PARK PLACE, NEW YORK 7, N. Y.

CIRCLE 135 ON READER-SERVICE CARD

Shore
HARDNESS TESTING


The Shore Scleroscope for testing the hardness of metals and other materials. Accurate, rapid, completely portable, non-marring. Over 40,000 in use. Pioneer American standard since 1907.
The Shore Durometer for testing the hardness of rubber and rubber-like materials. May be used free hand or mounted on Operating Stand. Conform to ASTM D676, D1484, & D1706.

Shore
INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXPRESSWAY
JAMAICA 35, N.Y., U.S.A.

CIRCLE 136 ON READER-SERVICE CARD

DAVIS

TRACE HYDROCARBON DETECTOR

Model 6500

● The Davis Trace Hydrocarbon Detector accurately and continuously detects and measures such organic compounds as hydrocarbons, aldehydes, ketones, alcohols, and amines. Based on a newly-developed *flame ionization technique*, this new detection unit features cubicle construction with indication and adjustable alarm functions. Recording is optional.

● A reliable, non-poisoning detecting method for most troublesome organic gases or solvents, the Davis Trace Hydrocarbon Detector incorporates a unique desensitizing arrangement that permits handling of higher concentrations (% by volume).

A portable version, Model 650 is also offered. This compact unit is ideal for laboratory or field analysis.

Model 6500 and Model 650 will be displayed at Booth 511, throughout the ISA Exhibit in Los Angeles.

INSTRUMENT DAVIS DIVISION

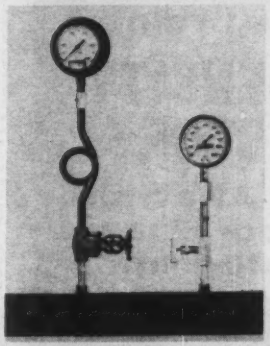
DAVIS INSTRUMENTS

DIVISION OF
DAVIS EMERGENCY EQUIPMENT CO., INC.

80 Halleck Street
Newark 4, New Jersey

CIRCLE 137 ON READER-SERVICE CARD

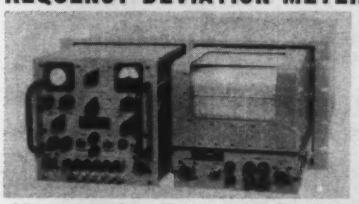
VALVE AND SIPHON



New M-7 Valve and Siphon Assembly for high-temperature gages replaces conventional pigtail-type siphon. Made of barstock, it contains an integral trap which forms a condensate seal between gage and process fluid.—*Anderson, Greenwood & Co., 5425 N. Rice Ave., Houston 36, Tex.*

CIRCLE 354 ON READER-SERVICE CARD

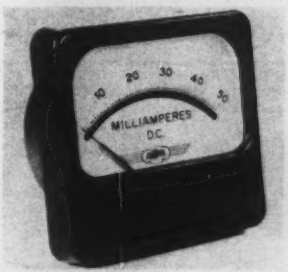
FREQUENCY DEVIATION METER



New portable Frequency Deviation Meter BTK-36A has recording unit. Full scale deflection of recorder is registered when frequency difference between primary and secondary frequency standards is only one part in 10^9, and it is possible to measure and record one part in 10^{10}, equivalent to a time difference of one second in 300 years. Model H-36A compares output of a 100-kc, 1-Mc, 2.5-Mc or 5-Mc secondary standard with output of a primary standard.—*Aircraft Radio Corp., Boonton, N. J.*

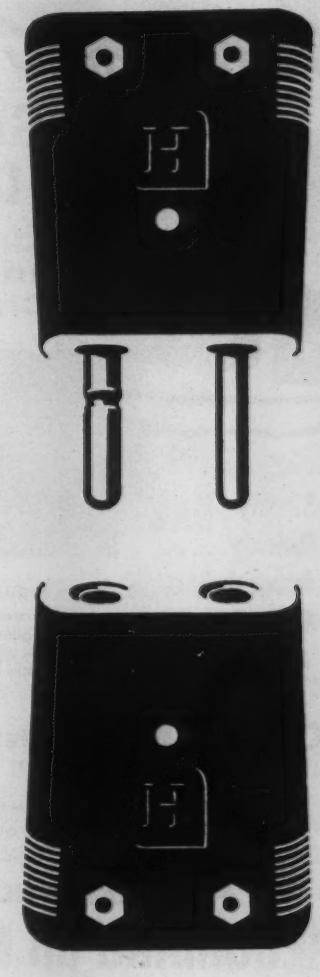
CIRCLE 355 ON READER-SERVICE CARD

PANEL METERS



New 0-50 ma DC Panel Meters feature anti-parallax mirrored scale, perfect tracking over entire scale, accuries of 1% or better, spring-mounted jewel bearings, mirror-polished steel pivots, etc. Pointer types include: knife edge, lance, and combinations. Sensitivites are 10,000 or 20,000 ohms/v.—*Airpax Electronics, Inc., Seminole Div., Fort Lauderdale, Fla.*

CIRCLE 356 ON READER-SERVICE CARD



QuiK-Konnect PLUGS AND JACKS

New Honeywell QuiK-Konnect Plug and Jack Assemblies provide fast, foolproof connection of thermocouples to extension wire, and thermocouple extension wire to instruments. Inserts of different diameter positive and negative poles insure correct polarity every time. Inserts are easily removed for field calibration change or replacement, and can be furnished in different metals to match thermocouple alloy. Honeywell Quik-Konnect Accessories include identos, cable clamps, and tube adapters.

Get complete details from your nearby Honeywell field engineer, or write today for Specification Sheet FS 005-3. Minneapolis-Honeywell, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

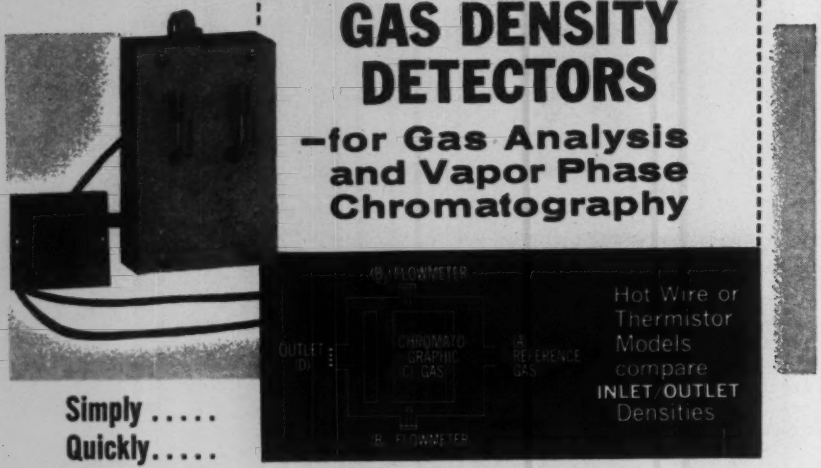
SINCE 1885

CIRCLE 133 ON READER-SERVICE CARD

GOW-MAC offers two new

GAS DENSITY DETECTORS

–for Gas Analysis and Vapor Phase Chromatography



Simply .....
Quickly.....
Accurately..
Reliably ....

SIMPLY with Nitrogen or Argon—

- Inert Carrier Gas
- Easily-built Gas Train
- Standard Electrical Circuitry (as for thermal conductivity)
- Normal Recorder Readout
- Quantitative Measurement

BUT—

- No Calibration to Standard Sample

VISIT BOOTH 132
National Chemical Exposition
Chicago, Illinois—Sept. 5th to 8th

GOW-MAC INSTRUMENT COMPANY
100 KINGS ROAD, MADISON, N. J., U. S. A. • Telephone: FRontier 7-3450

GAS ANALYSIS INSTRUMENTS SINCE 1935

CIRCLE 139 ON READER-SERVICE CARD

FIRST AND ONLY

RECORDING pH METER

Permanent pH Record • Simple to Operate • Adaptable • No Ink

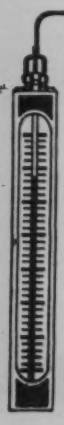
A pH meter and strip chart recorder in one. Line operated. Continuously indicating. Can record continuously for 31 days at one inch per hour. 0-14pH. With manual temperature compensator. Write for Bulletin No. 3R.

Price $245.00 complete, with Analytical protected pH probe unit

ANALYTICAL MEASUREMENTS, INC.

585 Main Street
Chatham, New Jersey

CIRCLE 140 ON READER-SERVICE CARD



TANK-O-METER

FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

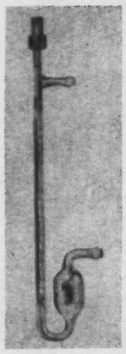
SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

UEHLING INSTRUMENT CO. 470 GETTY AVE., PATERSON, N. J.

CIRCLE 141 ON READER-SERVICE CARD

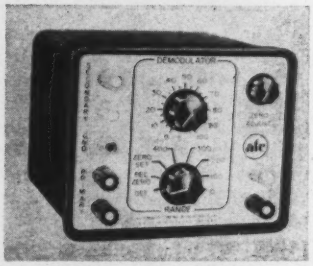
MANOMETRIC GAGE



New Laboratory manometer has positive closed-end, uses novel application of "O" rings and precision bore tubing. Permanent ceramic scale with white background for easy accurate reading is constructed as simple well-type "U" tube, is fully compensated to read in cm of Hg at 0°C, range of 0 - 20 cm. —*Roger Gilmont Instruments, Inc., 1 Great Neck Rd., Great Neck, N. Y.*

CIRCLE 357 ON READER-SERVICE CARD

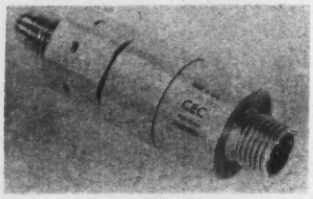
TRANSISTOR DEMODULATOR



New Atcotran 6101 E Transistorized Demodulator converts a-c millivolt output of linear variable differential transformer into true d-c voltage or current for operating either galvanometric or potentiometric recorders and indicators, magnetic amplifiers, and other d-c input devices. Signal conversion is through oscillator and demodulator circuits. Regulated 6-v output at 1600 cps is used to excite primary winding of differential transformer transducer and for phase comparison in the demodulator.—*Automatic Timing & Controls, Inc., King of Prussia, Pa.*

CIRCLE 358 ON READER-SERVICE CARD

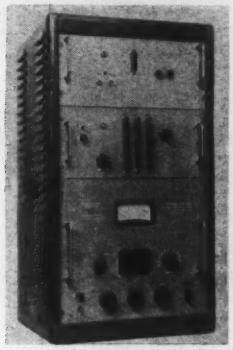
STRAIN GAGE TRANSDUCERS



Two new models Type 4-326 Strain-Gage Pressure Transducers utilize unbonded strain-gage principle with a four-active-arm spring type sensing element and a diaphragm force summing area. Pressure ranges are 0-100 to 0-5000 and 0-10,000 psia and psig, respectively.—*Consolidated Electrodynamics Corp., Subs. of Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 359 ON READER-SERVICE CARD

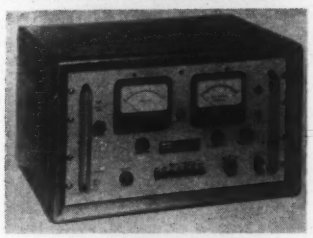
VARIABLE FREQUENCY P/S



New low-distortion variable-frequency Power Source Model LDS-1500 delivers continuously-variable voltage 0 to 1500 v and current 0 to 15 amp at 20 to 20,000 cps frequency. Amplitude stability is better than 0.01% and harmonic distortion only 0.1%.—*Krohn-Hite Corp.*, 580 *Massachusetts Ave., Cambridge* 39, *Mass.*

CIRCLE 360 ON READER-SERVICE CARD

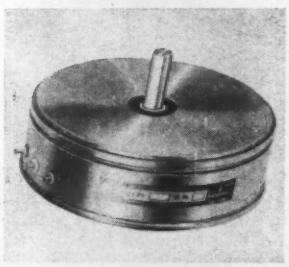
DEVIATION CALIBRATOR



New FM-monitor Deviation Calibrator Monocal 500 replaces five separate instruments: FM signal generator, low-distortion audio oscillator, audio frequency counter, selective receiver, and carrier-dropout visual indicator. Can be used directly with an FM monitor tuning to 12 mc or equipped with a 12-mc I-F strip.—*Advanced Measurement Instruments, Inc.*, 109 *Dover St., Somerville* 44, *Mass.*

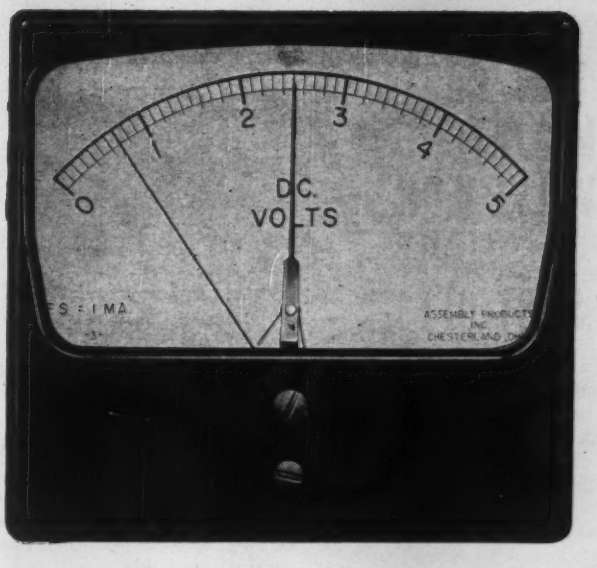
CIRCLE 361 ON READER-SERVICE CARD

MICROPOT



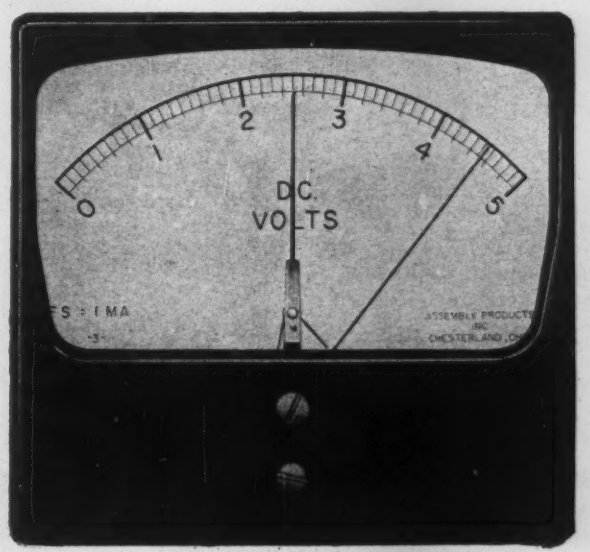
New 2490 Series of single-turn Micropot Potentiometers with a standard resistance range of from 100 to 200,000 ohms is 3″ in dia and 1″ lg. Resistance element is wirewound, maximum power rating is 6 watts at 40°C.—*Borg Equipment Div., Amphenol-Borg Electronics Corp.*, 120 *S. Main St., Janesville, Wis.*

CIRCLE 362 ON READER-SERVICE CARD



NEWS! API NOW HAS A CONTINUOUS READING METER-RELAY. No signal-sampling interrupters necessary. The CRMR indicates continuously, controls continuously, resets automatically. Built around an unrestrained D'Arsonval movement, it will monitor and control any variable translatable to analogous voltage or current values. Sensitive enough to operate on inputs as small as 5 millivolts or 10 microamps full scale, it will accept low-level signals without amplification. Compact as a panel meter, it needs only a power supply and load relay (both of which API can furnish) to make a complete little control system. Or, you can build it into an equipment control network. Bulletin S-2-1 will give you details on operation, along with specifications and price information. A copy is yours for the asking.

api **ASSEMBLY PRODUCTS, INC.**
CHESTERLAND 10, OHIO

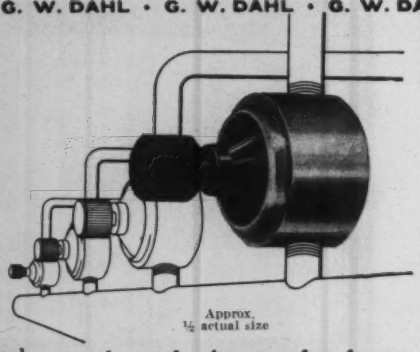


BA 2378

CIRCLE 142 ON READER-SERVICE CARD

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

LOW COST MINIATURE VALVE FOR TIGHT SHUT-OFF!



Approx. ½ actual size

Dahl FLEXI-PHRAGM packless diaphragm valve ideal for instrument air and other gas and liquid services . . . for isolating and/or testing the pneumatic circuit in process control loops.

Resilient diaphragms (Neoprene, Viton A or Buna) withstand deformation by slurries, trapped impurities (unfiltered service) . . . still provide positive shut-off. Diaphragms resume original configuration when valve is opened and particles washed away . . . even after prolonged closures.

Rated to 500 psig and 180°F. Closing torque only 10 lb.-in. (as rated) in dead end service. Brass bodies with ⅛" or ¼" NPT connections. Panel mounts available.

REQUEST complete data on this low cost, high performance valve. G. W. Dahl Co., Inc., 82 Tupelo St., Bristol, R. I.

G. W. DAHL CO., INC.

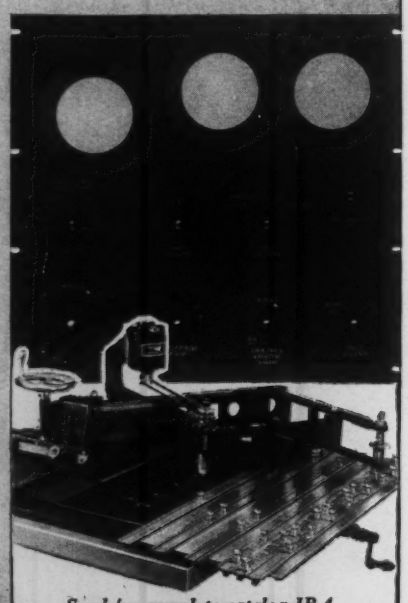
SPECIALISTS IN COMPACT VALVES AND CONTROLS

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

CIRCLE 143 ON READER-SERVICE CARD

any size panels

engraved in your own plant



Engrave 1-inch nameplates or 6-foot panels by unskilled labor.

Spindle covers 18¼" x 6" in one set-up — more than any other machine of its kind.

Bench type model I-R—$685.

Send for complete catalog JR-4

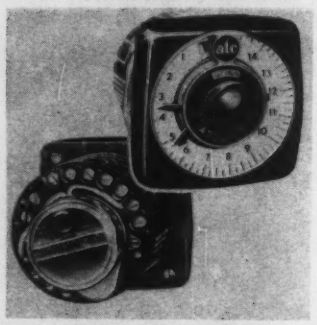
Visit Booth 5007, WESCON Show

neu hermes ENGRAVING MACHINE CORP.

154 WEST 14th STREET, NEW YORK 11, N.Y. IN CANADA 359 St. James Street West, Montreal, P.Q.

CIRCLE 144 ON READER-SERVICE CARD

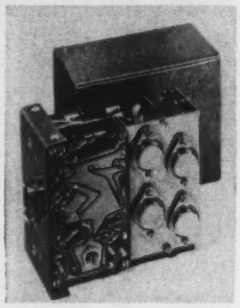
TIMER



New Series 305B Timer controls seven individual load circuits. Features include: 14-point terminal block, unique gear train which permits gears to rotate in one direction only, easy-to-read dial, optional locking knob, optional bezel mounting, choice of plug-in or non-plug-in.—*Automatic Timing & Controls, Inc., King of Prussia, Pa.*

CIRCLE 363 ON READER-SERVICE CARD

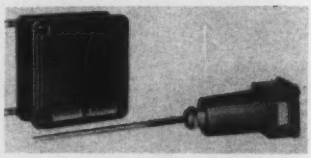
OPERATIONAL AMPLIFIER



New solid-state chopper and oscillator in all-transistorized Operational Amplifier Model TR-1 provide for stability of 10 μv in 24 hours, Loop gain is 10^7; output power from 0 cps to 1kc is ±50 v at 20 ma (for a ±25 v output current is 100 ma). Input impedance is approx. 1 megohm.—*Boonshaft and Fuchs, Inc., Hatboro Industrial Park, Hatboro, Penna.*

CIRCLE 364 ON READER-SERVICE CARD

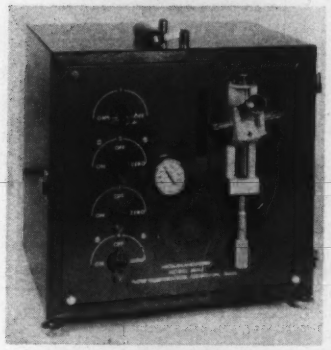
LEVEL CONTROLLER



New Transi-Level transistorized Level Control System for liquids, flowing solids, or powders incorporates an electronic medium-frequency control module in a probe unit requiring no coax cables, so that relay control unit can be mounted at any distance from the probe heads. Choice of probes is ceramic angle for use with powdered materials; heavy-duty for coal or gravel; flush probes, extension type, etc.—*Emerson Electric Mfg. Co., 8100 Florissant Ave., St. Louis 36, Mo.*

CIRCLE 365 ON READER-SERVICE CARD

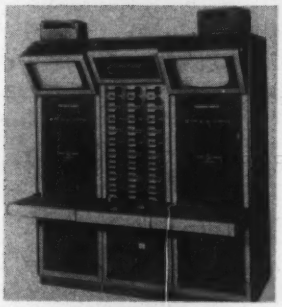
MICROMANOMETER



New Model MM3 Micromanometer measures pressure differences with accuracies as high as 6 millionths of one psi. Butyl alcohol is standard, other fluids including Hg can be used. Maximum range is 2" of manometer fluid used.—*Flow Corp.*, 11 *Carleton St., Cambridge* 42, *Mass.*

CIRCLE 366 ON READER-SERVICE CARD

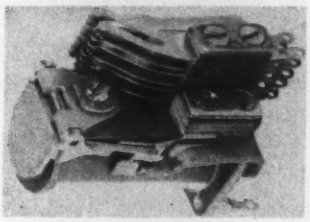
TIMING/CONTROL SYSTEMS



New Programmed Timing and Control systems provide accurate and reliable initiation and termination of various switching functions at preselected times, utilizing digital design concepts and modular construction. Programming is by punched tape, punched cards, magnetic tape, hard wire, patched panels, thumbwheel switches, etc. Bulletin 1M-1021.—*Curtiss-Wright Corp., Electronic Div., Box* 10044, *Albuquerque, N. M.*

CIRCLE 367 ON READER-SERVICE CARD

MECHANICAL LATCHING RELAY



New mechanical Latching Relay with manual reset, Series EML, is a modification of the Class E miniaturized telephone type relay. Available with d-c or a-c coils for up to 220 v. Has contact capacity of 13 springs.—*Automatic Electric Sales Corp., Northlake, Ill.*

CIRCLE 368 ON READER-SERVICE CARD

LUDLOW
SPECIALLY-DESIGNED
CUSTOM PAPERS
for your
special
RECORDING INSTRUMENT
Sophisticated instruments that chart critical variables demand sophisticated recording papers. That's why more and more recording instrument manufacturers are turning to Ludlow, patent holders of the first non-wax thermal and pressure sensitive chart papers.
Ludlow research and engineering design will go to work for you to create to your precise specifications the exacting, ultra-sensitive recording papers required to produce ultimate performance from a fine instrument... records free of failures or inaccuracies. Write Dept. CE-41 for literature and samples. Include your requirements or special problems.
LUDLOW PAPERS
WARE, MASSACHUSETTS
A DIVISION OF LUDLOW CORPORATION
Ludlow
CUSTOM
CHART PAPERS
40
30
20

CIRCLE 145 ON READER-SERVICE CARD

Name your service!

. . . there's a MARSH NEEDLE VALVE for it

Three great series of needle throttling valves —designed and built as only Marsh experience *in both* valves *and* instruments can make them. In materials for extreme range of services. In a full range of sizes and patterns, including panel mounted. For a wide range of pressures and temperatures.

Body and stem guides machined from solid bar stock for extra strength. Precision ground stems with fine pitched stem-threads for close regulation—tight shut-off. Long lived, but easily replaced "Marpak" moulded packing; Teflon in stainless steel valves. Deep inlet and outlet threads for tight make-up.

ALLOY STEEL SERIES
Working pressures to 10,000 psi.
316 STAINLESS SERIES
Working pressures to 6,000 psi.
416 STAINLESS SERIES
Working pressures to 10,000 psi.
Ask for bulletins covering full line

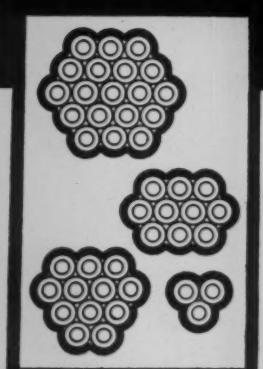
MARSH INSTRUMENT COMPANY
Dept. 42. Skokie, Ill.
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co. (Canada) Ltd., 8307 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant 1121 Rockwell St., Sect. 15, Houston, Texas. Eastern Seaboard Warehouse: Marsh Instrument Company, 1209 Anderson Ave., Fort Lee, N.J.

CIRCLE 146 ON READER-SERVICE CARD

PYRAMID "INSTRUPACK"

(TUBING BUNDLES)

POLYETHYLENE TUBES ENCLOSED IN VIRGIN PVC (VINYL) SHEATH



STANDARD
Tubing — ¼" O.D. x .040" Wall, .045" or .062" Sheath
Tubing — ⅜" O.D. x .062" Wall, .045" or .062" Sheath

Tough vinyl outer sheath with excellent chemical atmospheric resistance. Inside tubes are Polyethylene available in standard colors with pair of telephone wire leads. Lengths to requirements.

STOCK POLYETHYLENE TUBING—¼" O.D. x .040" wall and ⅜" O.D. x .062" wall, in standard colors.

PLASTIC COATED METAL TUBING—standards and specials to order.

Write for Bulletin PPI-59.

PYRAMID PLASTICS, INC.
856 W. Polk St., Chicago 7, Ill.

CIRCLE 147 ON READER-SERVICE CARD

MINI TV CAMERA

New Minicamera closed-circuit Television Camera, 9" long and less than 3" dia, is small enough to scan the interior of a 3" pipe, or to fit snugly into a standard hospital light fixture for a close-up view of surgical operations. Only essential components are in camera itself, others are housed in separate camera control unit.—*Fairbanks, Morse & Co., 100 Electra Lane, East Station, Yonkers, N. Y.*

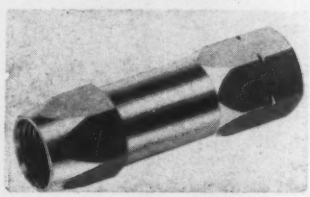
CIRCLE 369 ON READER-SERVICE CARD

STRAIN GAGE CEMENT

New B-3 Epoxy Cement for strain gages which sets in only three hours at room temperature (in minutes by application of infrared lamps) allows strain gage to be aligned while cement is setting up.—*Budd Co., Instruments Div., Box 245, Phoenixville, Pa.*

CIRCLE 370 ON READER-SERVICE CARD

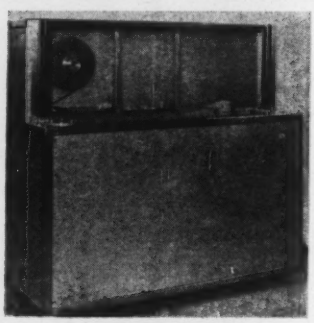
CHECK VALVE



New low-cost Check Valve in the Deccto Series features surge-proof operation, leak-proof check action and low pressure-drop. Operating pressure is 3000 psig and up, with 10 psi drop at rated flow. Surge-shock has been eliminated by unique hydraulic deceleration device.—*Bruning Co., Lincoln, Nebr.*

CIRCLE 371 ON READER-SERVICE CARD

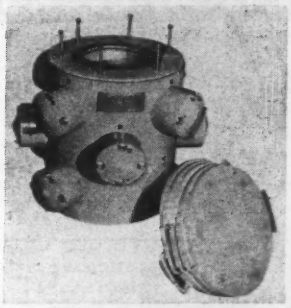
MAGNETIC TAPE CLEANER



New Model CT-2 Kinesonic Magnetic Tape Cleaner utilizes high-energy transducer for both sonic and ultrasonic cleaning of tape. Used for preventive manitenance by magnetic tape users. 4-page brochure.—*General Kinetics Inc., 2611 Shirlington Rd., Arlington 6, Va.*

CIRCLE 372 ON READER-SERVICE CARD

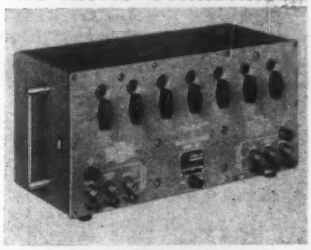
SCINTILLATION COUNTER



New Well Counter Model 90-2 measures low amounts of radio-activity in any given sample with sensitivity of 10^{-10} curies of K-40 above a background with a 20-min count. Consists of plastic scintillation well counter 24" high x 12" dia x 2" wall thickness with shielding of 5" of steel, and conventional electronic components with preset count or preset time indication. Circuitry consists of 12 DuMont 6363 - 3" multiplier phototubes with individual voltage controls and signal pre-amplifier.—*Franklin Systems, Inc., 2734 Hillsboro Rd., West Palm Beach, Fla.*

CIRCLE 373 ON READER-SERVICE CARD

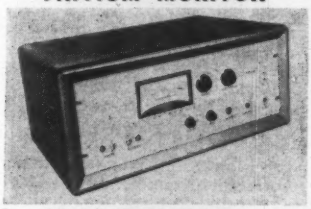
AC RATIO STANDARDS



New Series 1000 of precision Ratio Standards with certified a-c ratio accuracy to 0.0001% are precision transformer voltage dividers combined with precise resistive dividers. Basic ratio sections include high-frequency ac, low-frequency ac, and dc.—*Gertsch Products, Inc., 3211 S. La Cienega Blvd., Los Angeles 16, Calif.*

CIRCLE 374 ON READER-SERVICE CARD

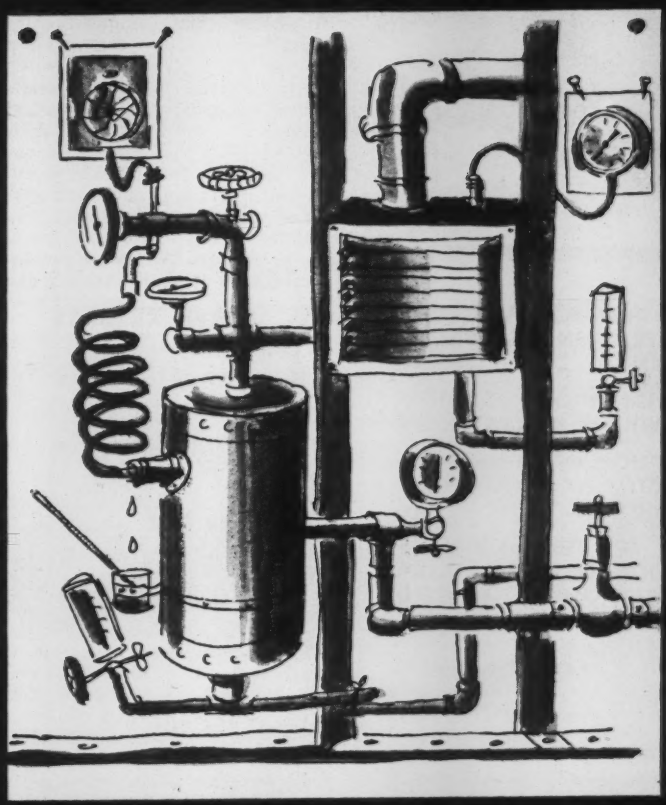
TRITIUM MONITOR



New Model H598 Tritium Monitor utilizing one electrometer tube plus transistorized circuitry has four linear ranges: 0-100$\mu c/m^3$; 0-1,000$\mu c/m^3$; 0-10,000$\mu c/m^3$; and 0-100,000$\mu c/m^3$. Reads directly in tritium concentration. Includes electronic alarm, provisions for remote meter indication and reset.—*Radiation Technology, Inc., 657 Antone St., N. W. Atlanta 18, Ga.*

CIRCLE 375 ON READER-SERVICE CARD

SEARCHING FOR A "SPECIAL"_____?



DOLLARS TO DOUGHNUTS IT'S STANDARD AT WEKSLER!

Why the confidence? We have manufactured literally *MILLIONS* of different types of instruments for measuring and recording temperature, pressure, humidity and time-of-operation. More than likely, the special you're looking for has been produced by *Weksler*. At worst, your problem will prove routine for our engineers.

Save hours, money and a lot of headaches by consulting us *first*. Other manufacturer's *"Specials"* are probably *Standard* with Weksler.

WRITE FOR NEW SPECIFICATION BULLETIN

WEKSLER INSTRUMENTS

"ORIGINATORS OF WORLD RENOWNED ADJUST-ANGLE THERMOMETERS"

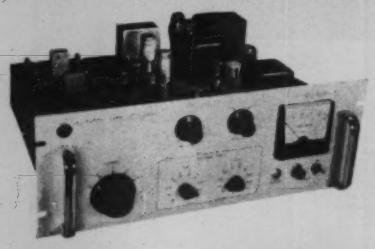
WEKSLER INSTRUMENTS CORPORATION

195 EAST MERRICK ROAD, FREEPORT, L. I., N. Y.

Indicating, Recording, and Controlling Instruments for Temperature, Pressure and Humidity

CIRCLE 148 ON READER-SERVICE CARD

ICF R-500 VLF RECEIVER



- PRE-TUNED TO 5 VLF TIME AND FREQUENCY STABILIZED CHANNELS
- PROVIDES RF OUTPUT COHERENT WITH 1 KC BEAT NOTE
- RECEPTION OF SIGNALS UNAFFECTED BY IONOSPHERIC CONDITIONS
- MAY BE USED FOR CALIBRATION OF LOCAL ULTRA STABLE OSCILLATOR AND DIGITAL CLOCKS

The ICF Model R-500 VLF Receiver, receives signals in the 14-30 kc band. It is pretuned at the factory to NAA, NBA, GBR, NPM and NPG. Transmission accuracy is good to small parts in 10^{11}. The R-500 is specifically designed for use with the ICF R-500-1 Phase Comparator, to calibrate local frequency standards and to start and adjust precision clocks and timing systems. The VLF pulse is heterodyned against an ultra-precision oscillator to produce a 1.0 kc beat note which may be displayed on an oscilloscope for synchronization or recorded directly on magnetic tape.

Specifications:

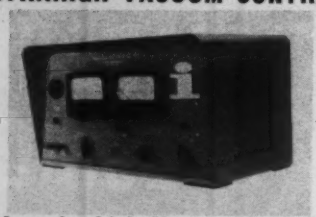
Input:	**Antenna 50-500 ft. long wire**
Output:	**1 kc 1.0V into 500 ohms RF 1.0V into 500 ohms**
Sensitivity:	**Less than 1.0 microvolts for 20 db S/N**
Weight (shipping):	**54 pounds**
Panel Size:	**7" x 19"**
Power:	**105-130V. A.C.**

INSTRUMENT CORPORATION of FLORIDA

P. O. Box 1226, Melbourne, Florida

CIRCLE 149 ON READER-SERVICE CARD

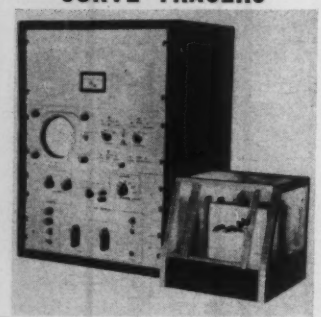
ULTRAHIGH VACUUM CONTROL



New ultrahigh Vacuum Gage Control Model 1020 combines extended pressure range with automatic emission current control. Used with any commercially available ultrahigh vacuum gage, it provides linear, stable measurement readings through range of 10^{-3} to 10^{-12} mm Hg. Emission current, variable from 0 ma to 10 ma, can be pre-set and automatically controlled throughout long-term pressure readings.—*Ilikon Corp., Natick Industrial Centre, Natick, Mass.*

CIRCLE 376 ON READER-SERVICE CARD

CURVE TRACERS



Two new reverse dynamic Curve Tracers for high-voltage diode testing provide 0-to-5-kv range at 60 cps in two steps with continuous verniers. Reverse current range is 20 ma f.s to 1 ma f.s. Model 1031-2A features true peak metering for current and voltage, plus oscilloscope plotting. Model 1031-2B provides calibrated oscilloscope plot. Brochure 1031-2B.—*Instrument Techniques, Inc., Henderson & Shoemaker Rds., King of Prussia, Pa.*

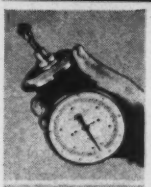
CIRCLE 377 ON READER-SERVICE CARD

SEMICONDUCTOR STRAIN GAGE

New DB-Series solid-state Strain Gages includes matched gages, gages for dynamic measurements, small gages for limited space requirements (0.1" gage length), and gage factors from −140 to +170, all incorporated in an epoxy matrix. Bulletin K-102. —*Kulite-Bytrex Corp., 50 Hunt St., Newton 58, Mass.*

CIRCLE 378 ON READER-SERVICE CARD

TACHOMETERS



TYPE "UO"
UNIVERSAL CENTRIFUGAL TYPE
With Overspeed Protection

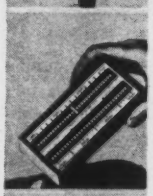
5 Ranges in each Instrument
Cat. No. 303 30-12,000 RPM
Cat. No. 314 45-18,000 RPM
Cat. No. 322 60-24,000 RPM
Cat. No. 346 120-48,000 RPM
Bulletin 751

STATIONARY TYPE
MODEL "J"

Sizes, 3", 4", 5½", 8", 10", and 20" dial diameter, flexible shaft driven.

Many standard ranges reading RPM, FPM, YPM, etc.

Bulletins 795, 796, 797



VIBRATING REED TACHOMETERS

Portable and Stationary Types. Measure speed by touch. Many different ranges from 900-100,000 RPM.

Bulletin 770

High Intensity
STROBOSCOPE

Model 510-AL
Range 60 — 15,000 RPM
Industry's Seeing Eye
Bulletin 781
Booth #213 ISA Los Angeles

HERMAN H. STICHT CO., INC.
27 PARK PLACE, NEW YORK 7, N. Y.

CIRCLE 150 ON READER-SERVICE CARD

Suppress lead wire errors with
REC's *new*
TRIPLE BRIDGE UNIT

Check these advantages in resistance temperature measurement applications:

- Suppresses large lead resistance changes (up to 5 ohms)
- Suppresses variable lead resistances at null and when unbalanced
- Suppresses unequal lead resistances
- Trims out calibration differences
- Multiple temperature ranges
- Standardized 10 mv. DC output
- Full line of auxiliary equipment

This precision-made, plug-in unit permits convenient change of full-scale temperature and corrects known calibration errors of sensor. Basic 10-channel unit provides 10 temperature ranges for each of 10 sensors.

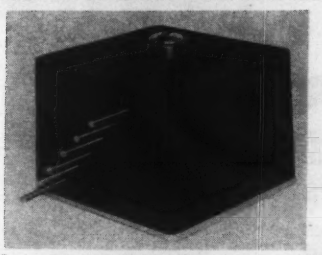
Write for Bulletin 86012

ROSEMOUNT ENGINEERING COMPANY

4901 West 78th Street, Minneapolis 24, Minnesota

CIRCLE 151 ON READER-SERVICE CARD

TRANSISTORIZED AMPLIFIER



New Model C70 3146 001 welded 1-cu in transistorized Amplifier is rated 5w, features high reliability, is potted in epoxy.—*Kearfott Div., General Precision, Inc.*, 1150 *McBride Ave., Little Falls, N. J.*

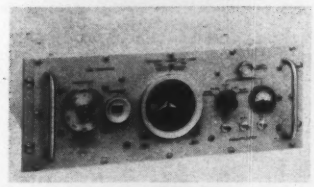
CIRCLE 379 ON READER-SERVICE CARD

DIGITAL MULTIPLE COMPUTER

New transistorized, digital, Multiple-computer L-3060 System performs 2,480,000 operations/sec and retrieves information from memory in less than a millionth of a second. Core memory access is to 144,000 words, random access to 3,250,000 words stored in magnetic disc files and magnetic tape storage files of 9,000,000 words.—*Librascope Div., General Precision, Inc., Glendale, Calif.*

CIRCLE 380 ON READER-SERVICE CARD

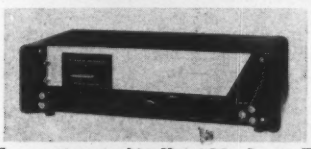
FREQUENCY DIVIDER



New Model 113BR Frequency Divider and Clock compares local time or frequency standards and hf or vlf broadcasts based on national standards. Overall time-comparison accuracy is ±10 μsec; fail-safe dividers and clock motor are impervious to transient noise or spurious signals. —*Hewlett-Packard Co.*, 1501 *Page Mill Rd., Palo Alto, Calif.*

CIRCLE 381 ON READER-SERVICE CARD

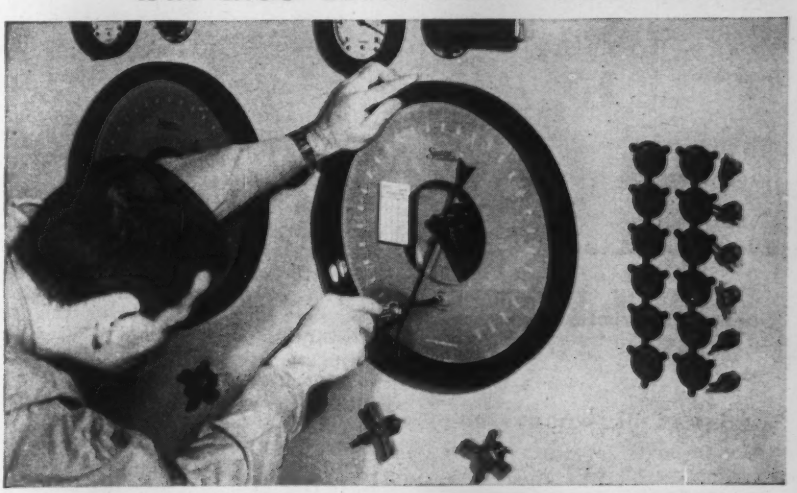
LOG FREQUENCY CONVERTER



New Model HLFC-120 Log Frequency Converter provides d-c voltage output proportional to logarithm of frequency of input signal from 0.5 to 100 v, features interchangeable plug-in log frequency discriminator networks with one, two, or three decade ranges from 5 cps to 20 kc. Illustrated unit has range 20 cps to 20 kc, accuracy of 2% of input frequency.—*Houston Instrument Corp., Box* 22234, *Houston* 27, *Tex.*

CIRCLE 382 ON READER-SERVICE CARD

Guaranteed accurate not only when it leaves our factory but also after field recalibration



You can recalibrate Seegers precision test gauges to their original accuracy of 0.10% FS over their entire pressure range. Simple screwdriver adjustment takes only a few seconds and requires no special tools or testing equipment. Only Seegers gauges have this *true* recalibration capability. Other product superiorities include Ni-Span C and stainless steel components, eye-ease green dial with white increments linear to ±.001", and bourdon bleed and flush valve as standard equipment. *Write for a copy of our comprehensive technical bulletin.* **Seegers Instrument Company**

515 West Main Street, Barrington, Illinois SGS-1-200

CIRCLE 152 ON READER-SERVICE CARD

Increased technical responsibilities in the field of range measurements have required the creation of new positions at the Lincoln Laboratory. We invite inquiries from senior members of the scientific community interested in participating with us in solving problems of the greatest urgency in the defense of the nation.

RADIO PHYSICS and ASTRONOMY

RE-ENTRY PHYSICS

PENETRATION AIDS DEVELOPMENT

TARGET IDENTIFICATION RESEARCH

SYSTEMS: Space Surveillance
Strategic Communications
Integrated Data Networks

NEW RADAR TECHNIQUES

SYSTEM ANALYSIS

COMMUNICATIONS: Techniques
Psychology
Theory

INFORMATION PROCESSING

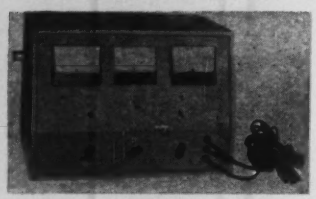
SOLID STATE Physics, Chemistry, and Metallurgy

A more complete description of the Laboratory's work will be sent to you upon request.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Research and Development
LINCOLN LABORATORY
Massachusetts Institute of Technology
BOX 35
LEXINGTON 73, MASSACHUSETTS

TRANSFORMER TEST SET



New Hypot Model 4075 high potential insulation breakdown and leakage Test Set meeting requirements of MIL-T-27A, Amendment 3, Paragraph 4.7.5 is a combination of two a-c Hypot test sets together with a phase shift network. Potential between the two windings can be varied, and is independently metered as required by basic military specification for transformer testing.—Associated *Research, Inc., 3777 W. Belmont Ave., Chicago* 18, *Ill.*

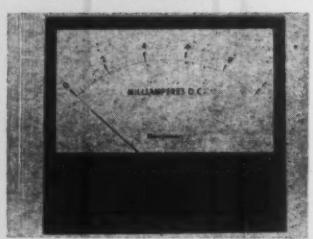
CIRCLE 383 ON READER-SERVICE CARD

PERISTALTIC TUBING PUMP

New Roll-Flex Laboratory Pump is electrically controlled and provides variable flow rate 90 to 500 ml/min. Pumping is by gentle, progressive kneading or peristaltic action on vinyl tube conveying the liquid or gas. A specially wound d-c motor is used in conjunction with a controller unit which houses a d-c power-supply and auto-transformer assembly to satisfy the high torque requirements of the pump, particularly at low speeds.—*Cole-Parmer Instrument and Equipment Co., 7330 N. Clark St., Chicago 26, Ill.*

CIRCLE 384 ON READER-SERVICE CARD

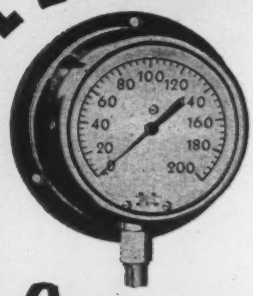
PANEL METERS



New series of rectangular Panel Meters, Style 42, (approx. 4.1" x 4.7") features all-metal construction, gasket seal to keep out dirt and moisture, and steel enclosures, scale length of 3.97", standard accuracies of 2%. Available as a-c and d-c voltmeters, ammeters, milliammeters, and microammeters.—*Helipot Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.*

CIRCLE 385 ON READER-SERVICE CARD

MARSHALLTOWN



Gauges

The right gauge for your specific needs

A complete line of gauges in stock available for early delivery. Gauges from 10-inches water pressure to 30,000 P.S.I. to meet your specifications on any equipment.

- Pressure
- Vacuum
- Compound
- Altitude
- Combination
- Diaphragm
- Hydraulic
- Special Purpose
- Dial Thermometer (Vapor Tension or Bi-Metal)

Let Marshalltown answer your gauge problems . . . write for information and prices.

MARSHALLTOWN MFG., INC.
A Subsidiary of The Electric Autolite Co.
MARSHALLTOWN, IOWA

CIRCLE 153 ON READER-SERVICE CARD

Ulta-fast Optics

for

INFRA-RED

Instrumentation

Reflective Optics

Cassegrain Systems

Paraboloids to f/.3

Off-axis mirrors

Refractive Optics

Si and Ge Optics

IR Windows

Aspherics

Mechanical Mountings

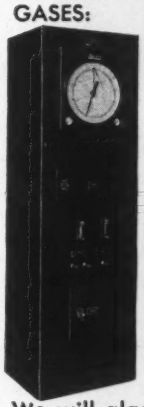
John Unertl Optical Co.

3551-55 East St.
Pittsburgh 14, Pa.

CIRCLE 154 ON READER-SERVICE CARD

PROCESS GAS ANALYZERS

THERMCO SPECIALIZES IN ANALYZERS FOR THE FOLLOWING GASES:



- Oxygen
  - Oxygen Purity
  - Trace Oxygen Measurements
  - Intermediate Oxygen Measurements
- Argon Purity
- Hydrogen Purity
- Hydrogen in Furnace Atmospheres
- Carbon Dioxide and —

Numerous other process control and portable instruments.

We will gladly supply you with complete information on these instruments . . . write:

THERMCO Instrument CORPORATION

Highway U.S. #20

LA PORTE, INDIANA

CIRCLE 155 ON READER-SERVICE CARD

DRY TRANSFER LETTERING

Instant Lettering brings you the finest, most meticulous lettering in the world instantly—by instantaneous dry transfer from type sheet to any smooth surface. Just press and it's there.

No trace of adhesive to sully artwork. Needs no equipment. Perfect on wood, paper, card, glass, metal, film . . . in fact any smooth surface. The right answer to the need for highest quality lettering for display panels, roughs, signs, labels, graphs, charts, TV cells.

10" x 15" SHEET ONLY $1.50

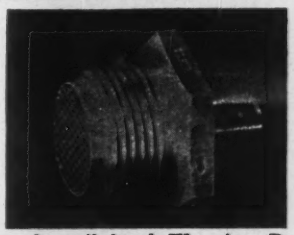
How it works:
rub on letter with pencil . . . lift away sheet

Send for sample and complete type chart

ARTHUR BROWN & BRO., Inc.
2 W. 46th St., New York 36, N. Y.

CIRCLE 156 ON READER-SERVICE CARD

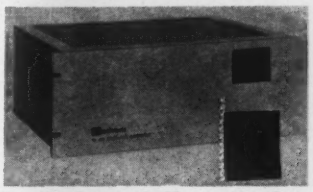
LEVEL WARNING SWITCH



New low-oil level Warning Device consists of a float switch which indicates absense of oil at the level of the switch. Perforated screen baffle protects float, also reduces oil turbulence in float chamber. Fits ports per AND 10050-16.—*Technical Development Co., 309A S. Chester Pike, Glenolden, Pa.*

CIRCLE 386 ON READER-SERVICE CARD

CHARACTER GENERATOR



New high-speed Character Generator TD-549 that can display up to 100,000 characters/sec. Solid-state device prints over a million words/min in any alphabetic language. Features extreme flexibility with 64 plug-in characters and codes. Accepts digital signals from computers, high-speed tape readers, and data links and presents information on CRT.—*Transdata, Inc., Box 1369, San Diego 12, Calif.*

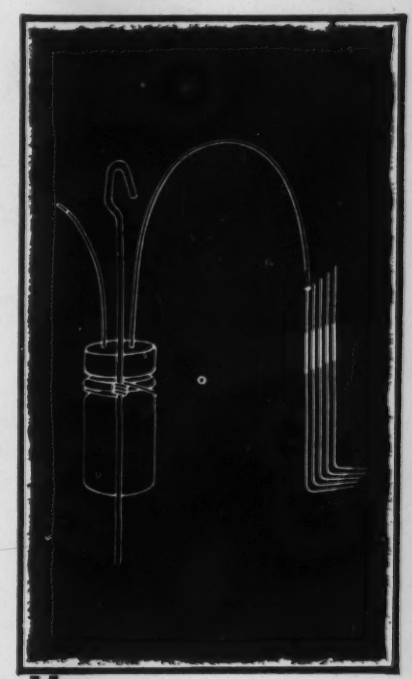
CIRCLE 387 ON READER-SERVICE CARD

VALVE ACTUATOR

New Electrothermal Actuator performs same primary function as cumbersome electromagnetic assemblies in applications requiring non-instantaneous operation. Produces forces 30 to 200 lb with mechanical motion ⅛" to 6". Integral electric resistance heater immersed in fluid or wax within actuator develops pressure as a result of thermal expansion which is transmitted to the piston through synthetic elastomeric seal. Linear, rotary, and positioning types available.—*Standard-Thomson Corp., Waltham, Mass.*

CIRCLE 388 ON READER-SERVICE CARD

CANNON PENS



UP TO A YEAR WITHOUT REFILLING

Cannon Meter Pens are easily installed as original or replacement equipment in all standard recording instruments. Produce accurate charts of maximum legibility. No blurring or smearing.

- Ends unrecorded intervals. Unaffected by pulsating flows, chart speeds, or rapid pen movement.
- Sealed ink supply prevents clogging from atmospheric contamination.
- Two-way capillary action ink flow eliminates smearing, blurring.
- Available in five sizes and angles. Special pens designed to customer specifications on request.

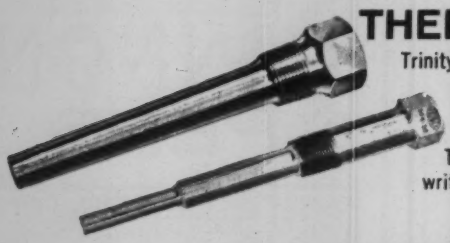
Write today for information.

AMERICAN METER CO. EST. 1836

AMERICAN METER COMPANY
INCORPORATED ESTABLISHED 1836

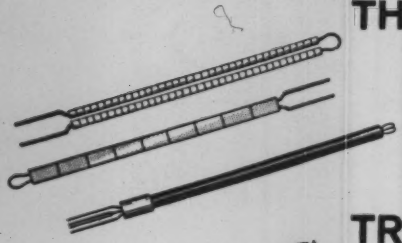
General Offices: Philadelphia 16, Pa.
Sales Offices in Principal Cities

CIRCLE 157 ON READER-SERVICE CARD



THERMOWELLS

Trinity Thermowells fit right, work right and last longer. Made of certified materials to the most exacting tolerances in the industry, Trinity Thermowells are backed by a written guarantee accompanying each standard well.



THERMOCOUPLES

A complete selection of wire materials and sizes, welded to meet or exceed the industry's standards assure you accurate performance in every installation when you select a Trinity Thermocouple.

TRINOX

Precise thermocouple assemblies sheathed in a protective well for miniaturized, or hard-to-reach points in a system or assembly. Also available in multi-point assemblies. Trinox is available in sizes down to .040" in diameter.

TRINITY

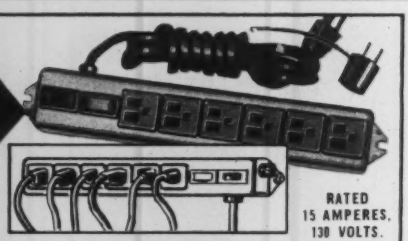
WRITE FOR COMPLETE MANUALS...

TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

Visit Us At The ISA Conference,
"Hawaiian Aloha Party"—Sept. 12-13-14
Room 3339 Biltmore Hotel, Los Angeles, 5 PM Till ??

CIRCLE 442 ON READER-SERVICE CARD

CUTS WIRING COSTS!
PLUG-IN
MASTER POWER CONTROL BOX
MODEL 24
$8.50



RATED 15 AMPERES, 130 VOLTS.

OFFERS YOU 6 SOCKETS WHERE YOU NOW HAVE 1

Heavy duty features insure long-life and complete utility for use on equipment or in shop or plant!

- Panel Mounted Fuse
- On-Off Switch
- Pilot Light
- Tough U. L. Cordset
- Molded Plug
- U. L. Approved Components
- Mounting Ears
- Silver Gray Seamless Hammertone Case
- "U" Ground Receptacles
- Adaptor Free

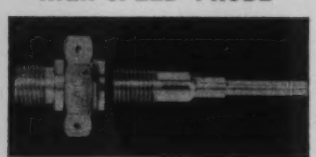
Model 24CB (Circuit Breaker Type) $10.50

SEND FOR LITERATURE
QUOTATION FOR SPECIAL UNITS ON REQUEST

WABER ELECTRONICS, INC.
Hancock & Somerset Sts. Phila. 33, Pa.

CIRCLE 159 ON READER-SERVICE CARD

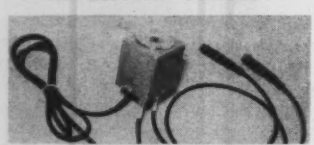
HIGH-SPEED PROBE



New high-speed Probe Type 3255, with a CP platinum sensor hermetically sealed and protected in a 316 s.-s. sheath has a response speed of less than 300 msec for one time constant. —*RdF Corp., Hudson, N. H.*

CIRCLE 389 ON READER-SERVICE CARD

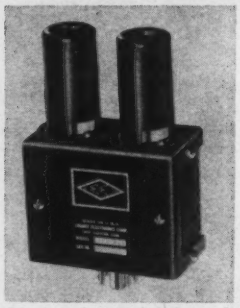
INTERVAL TIMER



New controlled Interval Timer, for line of Vernac direct-reading optical measuring instruments used in critical linear measurement, shuts off lamps automatically after an interval of 3 min.—*Simpson Optical Mfg. Co.*, 3200 *W. Carroll Ave., Chicago, Ill.*

CIRCLE 390 ON READER-SERVICE CARD

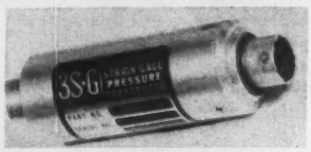
OPERATIONAL AMPLIFIER



New Model C/100/M is a low-cost, high-performance octal-base plug-in Operational Amplifier for analog computer and instrument applications. Gain is over 30,000 dc (open loop) with an output of 3 ma at ±100 vdc into a 33-K load. Provides full ± 100-v swing to 22 kc, with 0.6 μsec rise time and a bandwidth over 400 kc as a unity inverter into a 100-K resistive load.—*Embree Electronics Corp., West Hartford, Conn.*

CIRCLE 391 ON READER-SERVICE CARD

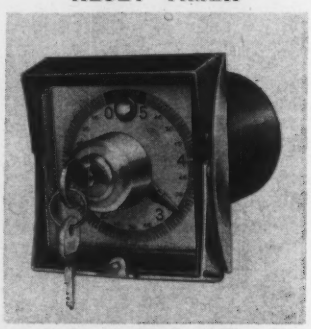
STRAIN GAGE TRANSDUCER



New silicon-semiconductor strain-gage Pressure Transducer which provides a 250-mv output without an amplifier with 10-v-to-30-vdc excitation has range 0-100 through 0-10,000 psig or psia. Can be used in any gaseous liquid media compatible with sulfuric anodized aluminum, passivated stainless steel, and Teflon. Operating temperatures −65° to +250°F; weight of airborne unit is ¼ lb.—*Fairchild Controls Corp., Subs. of Fairchild Camera and Instrument Corp., 225 Park Ave., Hicksville, L.I., N. Y.*

CIRCLE 392 ON READER-SERVICE CARD

RESET TIMER



New Bulletin 125 Cycl-Flex Plug-In Reset Timer now includes two desirable optional features: (1) timer setting by key lock and (2) pilot light to give indication that timer is on. —*Eagle Signal Co., Div. Gamewell Co., E. W. Bliss Co. Subs.*, 202-20th *St., Moline, Ill.*

CIRCLE 393 ON READER-SERVICE CARD

Satisfied with your process efficiency

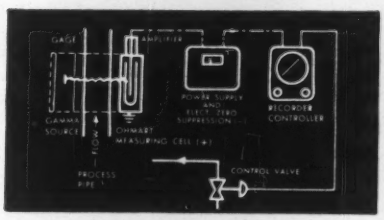
. . . if not, save with

ohmart

Nuclear Gages for Process Measurement and Control!

Obtain continuous, close limit control of:

- **Specific gravity and density of liquids.**
- **Percent solids or moisture of slurries.**
- **Level or interface position of liquids, solids, slurries.**
- **Dry solids flow (continuous weighing).**
- **Thickness or weight of moving webs of sheet materials.**



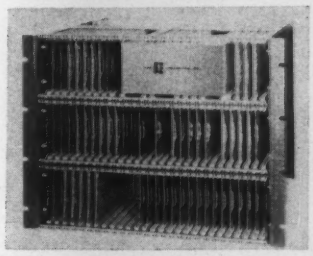
Typical Ohmart Density Control System where control of liquid density is by actuation of a valve. No part of the gage contacts the process material.

EXCLUSIVE OHMART ADVANTAGES: Ohmart gages have a precision and repeatability of ±2% of full scale or better, with ranges as narrow as 0.025 s.g.u. (4°Be., 5°Tw., 10°API, 5% solids) available. Ohmart systems operate with high signal-to-noise ratio; are unique in their stability and simplicity. Measuring cell has infinite life. Low-drift circuit requires only 5-minute semi-monthly standardization check. Rugged gage construction withstands severe atmospheric and mechanical conditions. Installation and maintenance costs are low. *Look to Ohmart to improve your process control. Performance to specification is guaranteed!* Write for literature.

THE OHMART CORPORATION
2246 Bogen St., Cincinnati 22, Ohio
Engineering Representatives in principal areas

CIRCLE 160 ON READER-SERVICE CARD

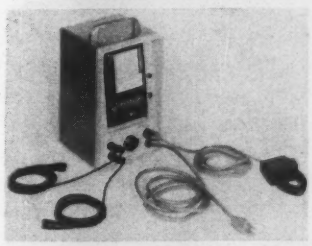
MAGNETIC MEMORIES



New Type 3300 Magnetic Memories, high-speed coincident-current, storage units with capacities 128 to 4096 words (4 to 64 bits/word), feature address-to-address cycle times of 6 μsec. Fully solid-state, they accept digital data either synchronously or asynchronously, store information in randomly specified or sequential addresses, and can be supplied with binary or binary coded decimal address.—*Rese Engineering, Inc., A and Courtland Sts., Phila. 20, Pa.*

CIRCLE 394 ON READER-SERVICE CARD

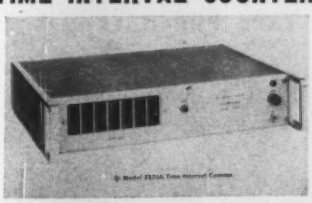
POWER TESTER



New portable Model 113 Power Tester for a-c voltage and current conditions has three voltage ranges and four current ranges. Can be used as direct-reading panel meter or as recorder. Equipped with test leads for measuring voltages and/or currents with the use of a clamp-on current transformer. Overall accuracy 3%.—*Rustrak Instrument Co., Inc., 130 Silver St., Manchester, N. H.*

CIRCLE 395 ON READER-SERVICE CARD

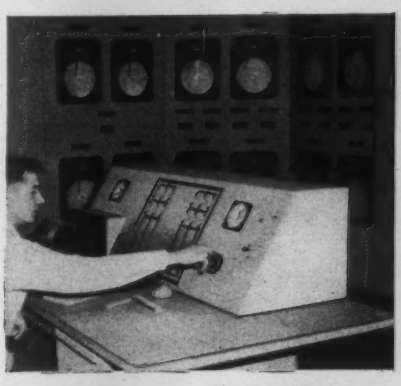
TIME INTERVAL COUNTER



New Time Interval Counter Model 5275A has 10-nanosec accuracy over its full range, which extends from 10 nanosec to 0.1 sec. Counted frequency is 100 mc, obtained from an external 1-mc standard which is multiplied 100:1 by an internal circuit. Neon columns give 7-place direct digital presentation in μsec with automatically-positioned decimal point. Counter can be reset to zero manually or by remote control.—*Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 396 ON READER-SERVICE CARD

AUTOMATION ECONOMY

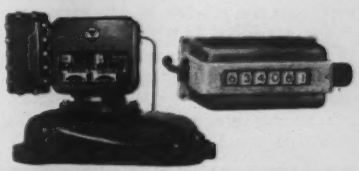


FOR YOUR SYSTEM

American® telemetering and telecounting equipment helps one man do the work of many ...in gathering fields, transmission and distribution systems.

One man at a central dispatching station instantly receives accurate flow and pressure readings from remote points and adjusts for demand with remote-set controllers.

For further information consult your American representative.



American Telecounters accurately transmit Base Volume Index indications of gas quantities computed to base temperature and base pressure conditions, to central locations.

AMERICAN® METER COMPANY
INCORPORATED (ESTABLISHED 1836)
General Offices: Philadelphia 16, Pa.
Sales Offices in Principal Cities

CIRCLE 161 ON READER-SERVICE CARD

PALMER

Mercury Actuated Dial Thermometers now in three types to suit any requirements

PALMER
°F
PATENTED
FULL 4½" DIAL FACE. Stem can be placed at any angle and case can be rotated to any readable position.
1 RIGID STEM DIAL THERMOMETER tapered bulb, interchangeable with standard industrial thermometer separable socket. (As illustrated above.)
2 WALL MOUNTED DIAL THERMOMETER with flexible connecting armor. Case adjustable to easy reading position.
3 FLUSH MOUNTED DIAL THERMOMETER for panel mounting with flexible connecting armor.
ALL THREE TYPES HAVE A FULL 4½" DIAL FACE.

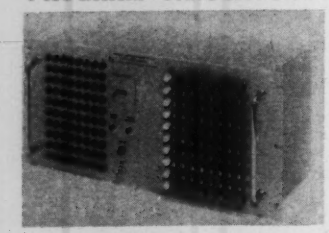
■ **for accuracy:** Mercury actuated . . . Compensated by Invar. Guaranteed Accurate 1 scale division. ■ **for angularity:** Can be adjusted to most readable position at any angle desired. ■ **for readability:** Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position. ■ **for interchangeability:** Also specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.

PALMER

PALMER THERMOMETERS, INC.
Norwood Ave., Cincinnati 12, Ohio
MFRS. OF INDUSTRIAL LABORATORY, RECORDING AND DIAL THERMOMETERS

CIRCLE 162 ON READER-SERVICE CARD

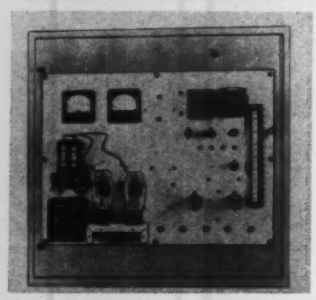
PROGRAM SIMULATORS



New Program Simulators are a series of integrated manual programmer and automatic punch control units for creation of automatic program tapes. Model PS-425 (illustrated) has 80-bit configuration, Model PS-426 has 96-bit configuration, and the PS-427 is a 120-bit model. In the PS-425, an 8-level, 10-row keyboard applies a 5, 6, 7, or 8-level code to the system for checkout purposes or punching of new programs.—*Electronic Engineering Co., of Calif.*, 1601 *E. Chestnut Ave., Santa Ana, Calif.*

CIRCLE 397 ON READER-SERVICE CARD

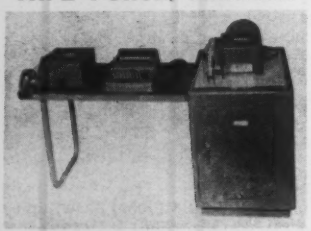
CONTROL REGULATOR



New electronic Control Regulator in the power control package of variable speed drives eliminates need for motor-generator sets. Automatically holds d-c motor speeds constant to within ½% of set speed and drift to no more than 0.05% with armature feedback.—*Tenney Engineering, Inc.*, 1090 *Springfield Rd., Union, N. J.*

CIRCLE 398 ON READER-SERVICE CARD

TAPE PUNCH/VERIFIER

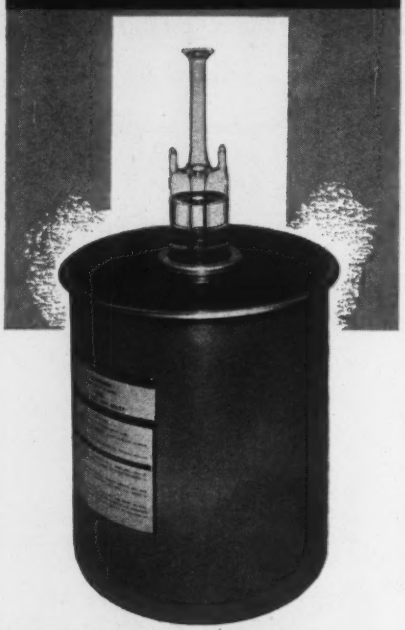


New Model D875 is a Universal Code Punch and Verifier system translating from an original document into paper tape machine language. Handles 5-, 6-, 7-, or 8-channel tape, any code structure. System consists of an alpha-numeric keyboard, a paper tape punch, a tape reader, and interconnecting circuitry.—*Systematics Div. of General Instrument Corp., Hawthorne, Calif.*

CIRCLE 399 ON READER-SERVICE CARD

THE EQUIPHASE* TRIPLE-POINT-OF-WATER CELL

a convenient standard for establishing a fixed temperature reference point.



EQUIPHASE Triple-Point-of-Water Cell establishes a reference temperature of 0.01°C with guaranteed accuracy of 0.0005°C. Unaffected by atmospheric pressure, contamination-free, easy and convenient to use. Just 17" high, 8" diameter.

This new laboratory standard establishes the precise point, 0.01°C, where ice, water, and water vapor coexist in equilibrium. The reference temperature point produced by the Equiphase Cell is accurate within 0.0005°C and may be quickly established with a minimum of technique or set-up.

The Equiphase Cell's accuracy cannot be easily duplicated with an ice bath. The triple-point-of-water is a physical constant — so precisely reproducible that it has been recently designated as a defining fixed point for the International Practical Temperature Scale of 1948 by the General Conference on Weights and Measures.

Reliability? Ease of use? Reasonable price? You get all these as well. But even more important — if you must have accuracy, this must be your standard.

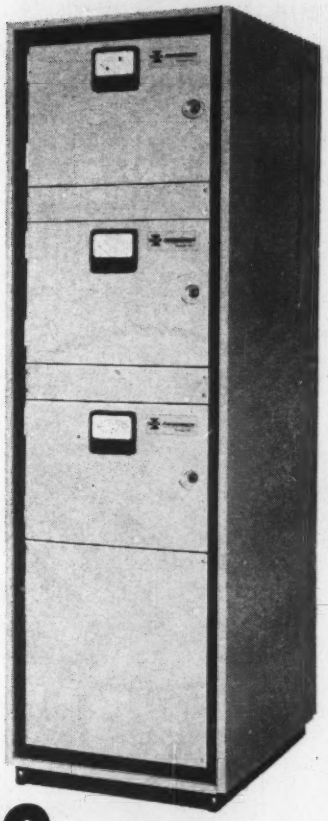
Please write today for complete information.

*TM

To put the sure in measurement

TRANS-SONICS, INC.
BURLINGTON, MASSACHUSETTS

CIRCLE 163 ON READER-SERVICE CARD



AC POWER REGULATOR

630 KVA

Smooth proportional control (5%-95% of rated power)

Rapid response (one cycle of supply voltage)

Introduces no power factor

Compact and lightweight

100% overload capability for five minutes

Accepts AC or DC input signal

$3450.00

3-phase model G6266 WJ-1 (shown) is rated 450 amps at 230, 460, or 600 volts.

Other single and 3-phase models rated from 40 amps to 1800 amps.

RI RESEARCH INCORPORATED

P.O. BOX 6164 Y, MINNEAPOLIS 24, MINN.

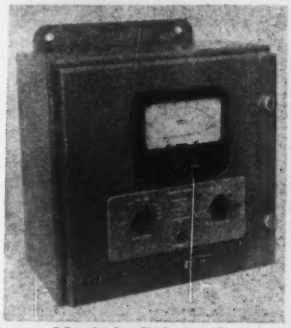
CIRCLE 164 ON READER-SERVICE CARD

INSTRUMENT BOXES

New GR-Series of explosion-proof Junction Boxes with lens covers includes copper-free cast-aluminum enclosures in eight sizes adaptable for housing meters, gages, and instruments.—*Killark Electric Mfg. Co.*, 3940 *Easton Ave., St. Louis* 13, *Mo.*

CIRCLE 400 ON READER-SERVICE CARD

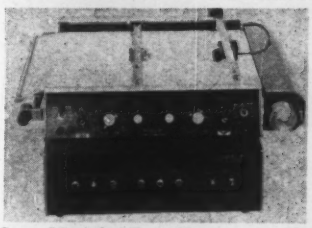
CONDUCTIVITY METER



New Model RA-3 Conductivity Meter, calibrated directly in NaOH-weight from 0 to 7%, can be supplied with automatic or manual temperature compensation 110° to 200°F. Cell selector switch permits use of single meter with a number of conductivity cells installed at different locations. —*Industrial Instruments, Inc.*, 89 *Commerce Rd., Cedar Grove, Essex Co., N. J.*

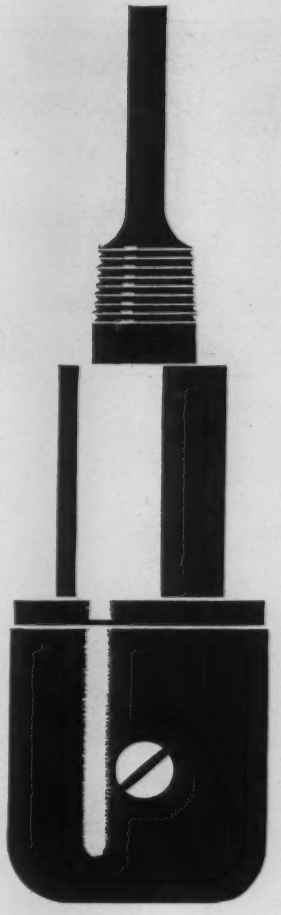
CIRCLE 401 ON READER-SERVICE CARD

TRANSPORT DELAY SIMULATOR



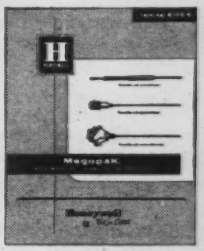
New Model 2D-5 Transport Delay Simulator system which reproduces time delay encountered in a process control, etc. combines a standard Autograf Model 2D X-Y recorder with its roll chart accessory and a Type F-2 line follower. Readout, a varying d-c voltage always proportional to the Y-coordinate of the recorded curve, can be used for control purposes.—*F. L. Moseley Co.*, 409 *North Fair Oaks Ave., Pasadena, Calif.*

CIRCLE 402 ON READER-SERVICE CARD



MegopaK THERMOCOUPLES

Honeywell's new line of hard-pack, small-diameter, mineral-insulated thermocouples. Available as bulk material (combination of wires, insulation and sheath); elements (with measuring junction); and as complete assemblies (with terminations and mounting attachments). From this one dependable source come thousands of other accessories to make your instruments perform at their very best.



Get details from your Honeywell field engineer, or write today for Catalog G100-4.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control SINCE 1906

CIRCLE 165 ON READER-SERVICE CARD

316 STAINLESS STEEL

Welded Bourdon Tube and Pressure Connection

A NEW ADDITION to MERCOID PRESSURE CONTROLS

Series D-41, 243, 541

316 stainless steel welded Bourdon tube. ¼" (316) stainless steel pressure connection. Nickel plated mechanism. Outside adjustments. Calibrated dial. Hermetically sealed mercury contact.

Operating ranges: 30" vac.-75 psig; 10-100 psig; 30-400 psig; 75-800 psig. and 100-1000 psig.— with varying differentials and electrical capacity to meet your application.

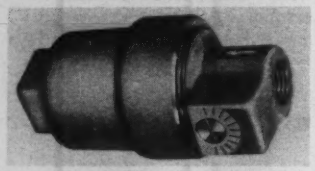
Three case styles: General Purpose NEMA 1; Weather-Proof NEMA 1A, 2, 3, 4; Explosion-Proof Class 1 Group C, & D; Class 2 Group E, F, G, NEMA 7, 9, 9A.

WRITE FOR BULLETIN 019

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

CIRCLE 166 ON READER-SERVICE CARD

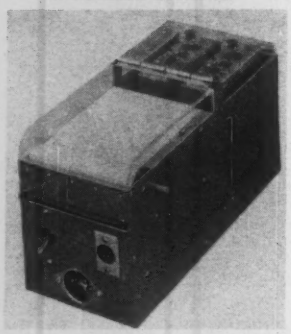
LOW FLOW RATE REGULATOR



New Fix-A-Flo Regulator holds rates from 0.1 to 3.0 gpm automatically constant regardless of line pressure variations. Half a turn on an adjusting screw sets flow rate with accuracy of ±5% of set point. Handles all types of liquids including lube and fuel oils, and process additives. Features straight-through flow design. Made of 18-8 stainless steel, withstands internal pressures to 1000 psig, operates at 9 psig or less, and has maximum inlet-to-outlet pressure drop of 125 psig.—*W. A. Kates Co., 430 Waukegan Rd., Deerfield, Ill.*

CIRCLE 403 ON READER-SERVICE CARD

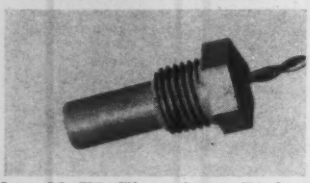
OSCILLOGRAPH



New two-channel pen-and-ink Oscillograph (11¼" x 4-3/16" x 5⅞", 12½ lb) has paper loaded from the top by lifting the hinged writing table. Galvanometer resistance is 1500 ohms; sensitivity is 1 mm/v, down 3 db at 60 cps. Recording width is 4 cm/channel. Standard paper speed is 1 or 10 cm/sec with speed change while paper is running.—*Keystone Development Corp., 2813 Westheimer Rd., Houston 6, Tex.*

CIRCLE 404 ON READER-SERVICE CARD

THERMISTOR PROBE



New IL-T5 Thermistor Probe Assembly for fluid measurement and control has range −40° to +265°F. Resolution is better than 0.01°F, time constant is approx. 5 sec. Nominal resistance is 36.4 ohms at 212°F, 364 ohms at 100°F, 649 ohms at 77°F, and 1448 ohms at 32° F. Molded of epoxy resin easily installed in ¼" NPT fittings.—*Instrumentation Lab., 108 Cummington St., Boston 15, Mass.*

CIRCLE 405 ON READER-SERVICE CARD

Save Time, Money Speed Installations with . . .

P-W TUBING & CABLE SUPPORT SYSTEMS

P-W's TYPE "E" (PUNCHED BOTTOM) TRAYS—FOR POWER AND CONTROL CABLES AND INSTRUMENT TUBING—ALTHO LESS EXPENSIVE, ARE STRONGER, VERSATILE AND SUPERIOR. TUBING AND CONTROL CABLE CAN BE DROPPED OUT ANYWHERE.

Engineers, Contractors and Installers look for QUALITY, LONG LIFE, AND LABOR SAVINGS in their supports. That's why more and more users are turning to P-W. Among our outstanding improvements are: CONNECTIONS that are quick and easy to install—PRE-CUT SYSTEMS saving installation time—EXTENSION CONNECTORS eliminating field cutting to complete runs—ADJUSTABLE HORIZONTAL and RISER CONNECTORS to go over, under or around pipes, trusses, columns, etc.—BUILT-IN ADJUSTABLE DROP-OUT SECTIONS eliminate cutting out bottom of tray—STRAIGHT SECTIONS available in lengths up to 16' (33 1/3% less connectors and less installation time over 12' lengths).

P-W SUPPORTS are available in hot dip galvanized steel or aluminum, in LADDER, EXPANDED METAL and SOLID TRAYS in addition to Type "E". All systems are interchangeable. Write for Catalog 858-A.

For the utmost in service, contact the appropriate Representative in your territory or P-W direct, regarding inquiries and placing orders.

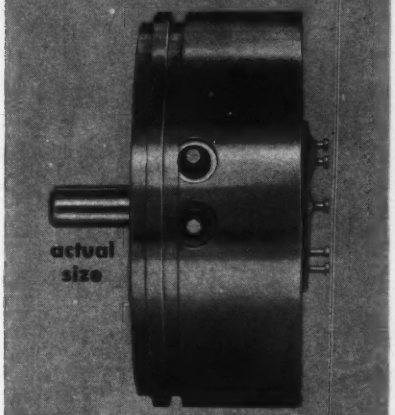
P-W INDUSTRIES

11200 Roosevelt Blvd.
Philadelphia 15, Pa.

See us at Booth #407—ISA Instrument Show

CIRCLE 167 ON READER-SERVICE CARD

DIGITAL SYNCHRO



Reliability — 6 years mean-time-to-failure

Highest Speed — 6 million counts per minute

Optisyn® is a unique incremental encoder . . . a direct replacement for analog servo components.

Optisyns are excellent for:

- Counting
- Numerical control
- Digital tachometers
- Shaft encoding
- Angle transmission systems

Specifications

- Reliability — 50,000 hrs. operating life or 200 million revolutions
- Low Torque — .05 in.-oz.
- Speed Range — 0-3000 rpm
- Size — Model 23, shown above, 2.3" dia.
- Broad line of models covering resolution range of 100 to 4096 counts per shaft revolution

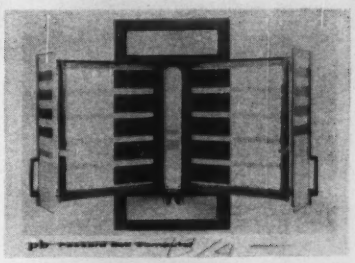
Send for Technical Bulletin No. 611 or call Stoneham, Massachusetts, 438-3900

DRC **DYNAMICS RESEARCH CORPORATION**
38 Montvale Ave., Stoneham, Mass.

See at ISA Show, Booth #116-B

CIRCLE 168 ON READER-SERVICE CARD

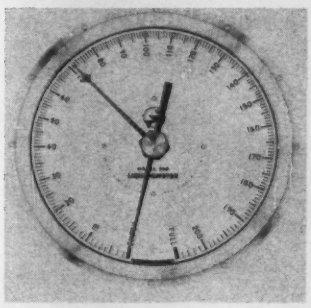
DIGITAL MODULES CASE



New rack-mounted Digital Modules Case Model MC250 with capacity of 250 modules occupies less than 30" of panel height in a standard 19" rack. Slides out and opens like a book for ready accessibility to modules and wiring. Incorporates provisions for 200 signal lights.—*Packard Bell Computer, Subs. of Packard Bell Electronics, 1905 Armacost Ave., Los Angeles 25, Calif.*

CIRCLE 406 ON READER-SERVICE CARD

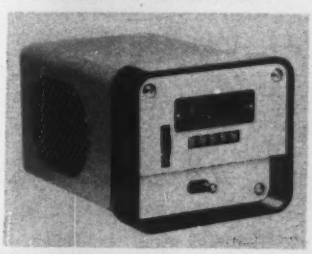
TANK CONTENTS GAGE



New fully-automatic Model 580 Tank Contents Gage for measurement of chemicals in storage tanks, including high-pressure chemical applications up to 1000 psig, has parts within the tank of Type 316 s.s. Magnetic coupling provides precision drive action with accuracy of ½%.—*Liquidometer Corp., 41-03 36th St., Long Island City 1, N. Y.*

CIRCLE 407 ON READER-SERVICE CARD

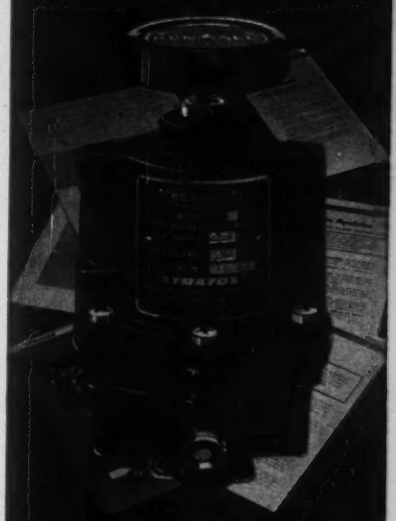
WORD COUNTER



Three new models of Word Counters are for traffic flow survey on printing telegraph circuits or for pulse-count summarizing. Interchangeable shaft gears afford handling wide range of character speeds and lengths. Model WC-6A is for 117 v/60 cps; WC-7A for 220 v/50 cps; and WC-8A for 117 v/50 cps.—*Western Apparatus Co., Div. of Comptometer Corp., 5600 Jarvis Ave., Chicago 48, Ill.*

CIRCLE 408 ON READER-SERVICE CARD

KENDALL/GOVERNAIRE



SEND FOR CATALOG ON

PRECISION AIR REGULATORS

Large balanced supply and relief valves provide rapid response with precise control plus maximum flow for minimum size.

Kendall is a direct acting, spring actuated, bleed type valve. Governaire is pilot assisted. Both lines have a unique boost action with increased flow rate that offsets downstream pressure losses. Both are immune to supply pressure variations and suited to either high-flow or dead-end applications. With the Kendall/Governaire lines, Stratos offers the largest selection of standard and special precision pressure regulators, relays and volume boosters in the industry.

For your copy of the Stratos Engineering Manual and Data Sheets illustrated above, write

STRATOS®
A DIVISION OF
FAIRCHILD ENGINE & AIRPLANE CORPORATION
Bay Shore, L. I., N. Y.

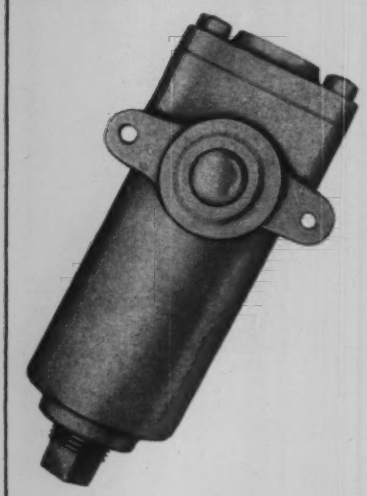
CIRCLE 169 ON READER-SERVICE CARD

Save time, trouble!

Determine cause of engine shut-down with

Amot

Model 2400 Indicating Relay



Amot Model 2400 Indicating Relay tells which engine hazard caused shut-down, (whether low oil pressure, high water temperature or what).

Uses air or gas pressure to function. One Relay used for each safety component in system.

If condition is dangerous, Relay will act to vent Safety Control and shut down engine. Quick check of indicator shows cause of shut-down. Each Relay automatically resets itself when engine is again started. Can be easily installed on existing engines. For information on components, controls or systems, ask for Bulletin Q-5.3.

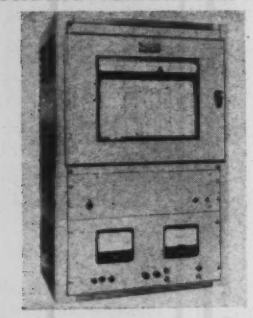
Amot controls CORPORATION

THERMOSTATS CONTROLS SWITCHES VALVES SAFETY CONTROLS

4156 FIRST ST. • RICHMOND, CAL., U.S.A.

CIRCLE 170 ON READER-SERVICE CARD

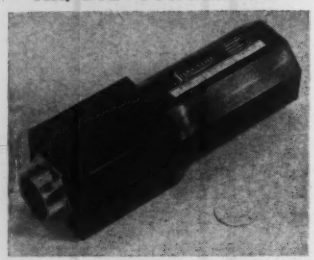
RECORDING IONIZATION GAGE



New Televac Recording Ionization Gage with logarithmic output, permits measurement of vacua form 10^{-3} to 10^{-10} mm of Hg on a single scale, and monitoring and control for automated processing. Heart of the instrument is a logarithmic electrometer which measures current from 10^{-11} to 10^{-4} amp, using a specialized diode as the log circuit element.—*Fredericks Co., Bethayres, Pa.*

CIRCLE 409 ON READER-SERVICE CARD

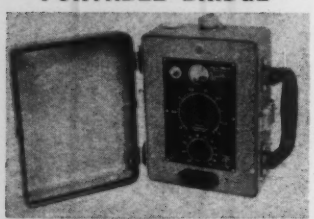
AN/DIG CONVERTER



New miniaturized electromechanical Converter, Model 791-S, is primarily for low-speed conversion of linear data into digital form. Can be modified to perform as a digital servo, to convert nonlinear data into digital form, and to perform digital-to-voltage conversion functions. Meets MIL-E-5400C and MIL-E-5272C.—*Librascope Div., General Precision, Inc., Glendale, Calif.*

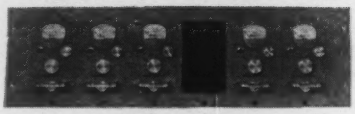
CIRCLE 410 ON READER-SERVICE CARD

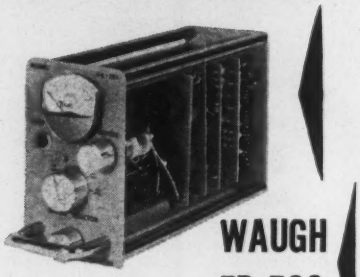
PORTABLE BRIDGE



New transistorized portable, battery-operated Solu Bridge, Type RB2, is available in several hundred different calibrations for services ranging from ultra-pure water to the most conductive acids and bases. It incorporates an a-c Wheatstone Bridge operating at 400 cps, and utilizes a center-reading null meter as balance indicator.—*Industrial Instruments, Inc., 89 Commerce Rd., Essex Co., Cedar Grove, N. J.*

CIRCLE 411 ON READER-SERVICE CARD





WAUGH FR-500

MODULAR Frequency-to-D.C. CONVERTER

The new Waugh FR-500 is a modular frequency-to-d.c. converter designed to permit the monitoring or recording of signals from several sources simultaneously.

Five converter modules mount in a 7x19" rack panel, with six converters on a 24" panel.

Each converter produces three outputs precisely proportional to the frequency of the a.c. input signal from flow sensors, tachometers, photo cells, electro-magnetic coils, or FM systems. Output may be read directly on the panel meter. Pulse and d.c. outputs are also provided to drive oscillographs, counters, and a wide variety of other electronic indicators, recorders or controllers.

A power supply for up to 25 converters, and a master calibration oscillator, with an an accuracy of ±.01% of reading fit on a single panel which can be mounted on the same rack as the FR-500. Individual, integral power supplies are also available with each module.

SPECIFICATIONS

Frequency Range	5 cps to 3.2 kc. (10 kc. available)
Input Amplitude	5 mv. to 100 volts
Linearity	0.1% of full scale
Ripple	±0.1% full scale peak-to-peak max.
Pulse Output	10 ma. into 250 ohms
D.C. Output	0 to 5 volts

Request Bulletin 112 for complete specifications

Waugh

Engineering Representatives in Principal Cities

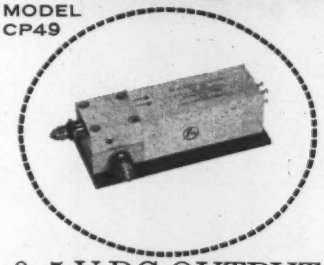
WAUGH ENGINEERING COMPANY

7842 Burnet Avenue, Van Nuys, Calif.
STate 2-1710

CIRCLE 171 ON READER-SERVICE CARD

PACE

MODEL CP49



0-5 V DC OUTPUT
PRESSURE
TRANSDUCER
FOR OPERATION to 250°F

Ranges: 0.5 to 2,500 psi — gage or differential . . . 5 to 2,500 psi — absolute

Accepts corrosive fluids — both sides

½ % full scale accuracy

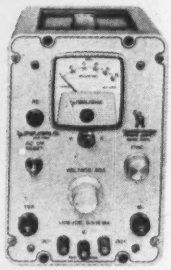
Designed for voltage controlled telemetering and other DC systems

PACE
engineering company
13035 Saticoy Street
North Hollywood, California
TRiangle 7-7139

CIRCLE 172 ON READER-SERVICE CARD

WIDE RANGE

MODEL
105TA



WITH

ROBOTEC
overload and short protection
and
HEATRAN
electronic dissipation control

$239.50
FOB FACTORY

WESCON
BOOTH
2705

SEMICONDUCTORIZED
POWER SUPPLY
1-100 VDC
0-0.5 AMP

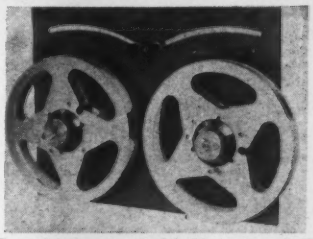
High efficiency, stabilized solid state DC power supply with .05% regulation, 1 millivolt ripple, .025 ohm source impedance, 50 microsecond response time, 55-440 cycle input.

IMMEDIATE DELIVERY

Power Designs inc.
1700 SHAMES DRIVE, WESTBURY, NEW YORK
EDgewood 3-6200 (LD Area Code 516)

CIRCLE 173 ON READER-SERVICE CARD

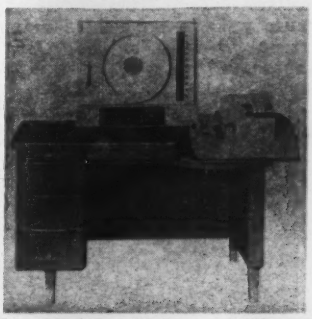
PERFORATED TAPE HANDLERS



New high-speed, bi-directional Perforated-Tape Handlers are made as Dykor Model 4588 which handles 1,000 ft of 5-to-8-level 4-mil tape interchangeably at speeds up to 150 characters/sec (15 ips), and Dykor Model 4599, which functions at speeds up to 250 characters/sec (25 ips). Both are bi-directional and have 10½" reels.— *Digitronics Corp., Albertson Ave., Albertson, L. I., N. Y.*

CIRCLE 412 ON READER-SERVICE CARD

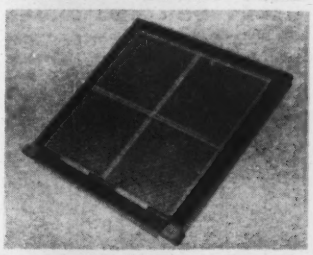
ELECTRONIC WEIGHER



New Model Q high-speed Electronic Weigher balances and prints out in less than 3 sec, as cars roll by on rails. A servo null-balance balancing system, it uses a signal from strain gage load cells while the servo mechanism detects a phase and as a result drives a load-balance potentiometer to a null-balance condition. Bulletin ED-17.— *Fairbanks, Morse & Co., Electronics Div., 505 Oakwood Ave., West Hartford 1, Conn.*

CIRCLE 413 ON READER-SERVICE CARD

PLASTIC MEMORY CORE



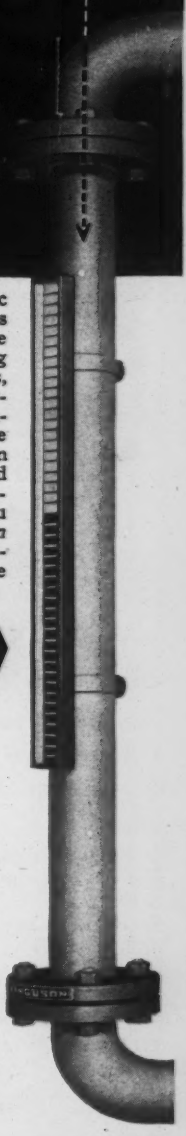
New plastic Memory Core Frame of IBM's computers is made with compound formulation F.M.4005 which gives the frame the ultimate in dimentional stability under widely varying atmospheric conditions, high impact and flexural strength, minimum shrinkage values, high dielectric strength, and high heat resistance.— *Fiberite Corp., Winona, Minn.*

CIRCLE 414 ON READER-SERVICE CARD

Lock your hazards in a

SOLID-WALL CHAMBER

and gage safely and accurately with JERGUSON MAGNETIC GAGES



Jerguson Magnetic Liquid Level Gages give you absolute safety when dealing with problem liquids, toxic gases and corrosion. You completely eliminate the dangers inherent in glass, its gaskets and threaded connections . . . for you *lock your hazards in a solid-wall chamber*, flanged to the vessel being gaged.

the only gage of its type!

- unique safety design prevents gases from escaping
- measuring device is inside the stainless steel chamber
- scale is mounted outside the chamber; magnetically actuated through the chamber wall
- level is accurately shown in red, contrasted with silver above
- job designed, correlating pressure, temperature and specific gravity
- four different models
- available with electric alarms
- for liquid level and interface indication

Patented

For complete data write for Catalog No. 388

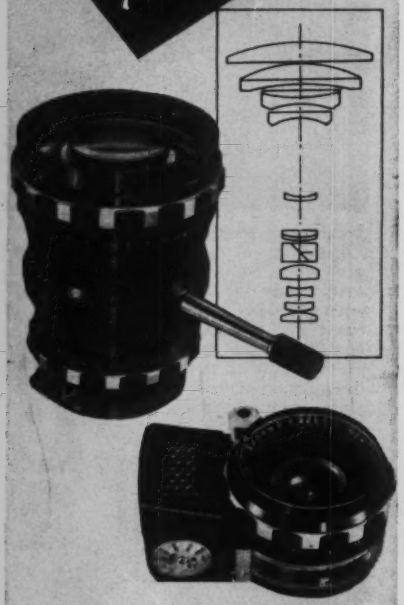
JERGUSON
Gages and Valves for the Observation of Liquids and Levels
JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices in Major Cities

See exhibited at ISA Show, Booth 903

CIRCLE 174 ON READER-SERVICE CARD

ARE YOUR OPTICAL REQUIREMENTS

Very Special?



the lens you need probably is available in the extensive Schneider line of over 300 lens types

Whether for tracking, chemical determination or analysis, or any other usual or unusual lens application, it will pay you to first check your lens requirements with Schneider . . . world's leader in precision optics. Possibly, the exact lens system you require may be standard within Schneider's extensive line . . . or a simple, inexpensive modification may be your answer. In either case, time and costs can be cut appreciably . . . with all the assurance of quality the name Schneider provides. A request on your company letterhead will bring you illustrated catalog and other literature.

Schneider **LENSES**

Classics of Optical Precision

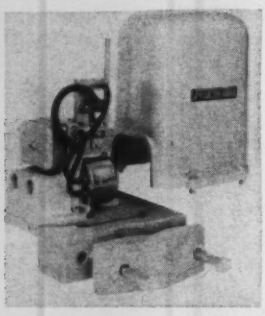
BURLEIGH BROOKS, INC.

420 Grand Avenue, Englewood, New Jersey

CHICAGO • HOLLYWOOD • ATLANTA • DALLAS

CIRCLE 175 ON READER-SERVICE CARD

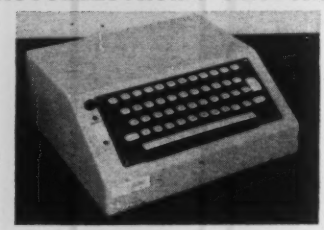
PNEUMATIC DC TRANSMITTER



New D-C Transmitter, Type 19A, measures direct-current values "in the tens or hundreds of thousands of amperes" in industrial applications by sensing at a calculated distance the magnetic field established by d-c flow through a bus bar conductor, which deflect a rod-shaped magnet in the transmitter. A flapper-nozzle detector in a pneumatic force-balance system furnishes 3-15 psi pneumatic output. Accuracy is to ±0.5% of maximum current value.—*Foxboro Company, Foxboro, Mass.*

CIRCLE 415 ON READER-SERVICE CARD

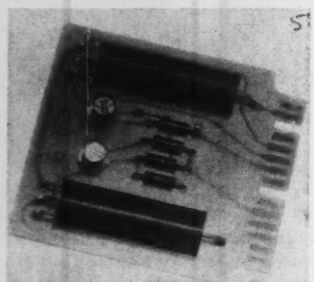
PHOTOELECTRONIC KEYBOARD



New K-144 44-key alpha-numeric Keyboard features photoelectric encoding technique which permits the generation of any standard or special 5-, 6-, 7- or 8-bit binary code. There are 10 data channels available for any combination of binary code signals and signals for strobe, dual logic, tab, shift, etc.—*Invac Corp.*, 14 *Huron Dr., Natick, Mass.*

CIRCLE 416 ON READER-SERVICE CARD

RELAY BUILDING BLOCK

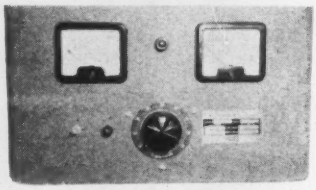


New Digital-system Module comprises two transistor-driven high-speed reed relays for use as a switch or gate. Operates directly from solid-state logic without buffering.—*Control Equipment Corp.*, 19 *Kearney Rd., Needham Heights* 94, *Mass.*

CIRCLE 417 ON READER-SERVICE CARD

CADILLAC POWER SUPPLIES

Built to your Needs Priced within your Budget



SELENIUM—SILICON

.1 to 1,000 K.W.

CYCLOMATIC AUTOMATIC TIMERS CURRENT CONTROLLED

operate on 2 amperes to 10,000 amperes

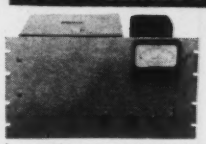
CADILLAC PRODUCTS CO.

571 Webster Avenue
New Rochelle, N. Y.
NEw Rochelle 6-3476

CIRCLE 176 ON READER-SERVICE CARD

SPELLMAN

HIGH VOLTAGE POWER SUPPLIES



MODEL RG-30

Continuously Variable 15-30 KV Regulated DC Power Supply with Regulated Focus Voltage Tap

A continuous duty DC supply with highly filtered outputs and regulations better than 0.5% at 1 ma.—no load to full load. A variable focus tap 4-6 KV for use with 5WP11, 5TP4 and flying spot tubes. Dimensions: 19" wide x 10½" high x 13" deep.

With HV meter $375 Net Less meter $325 Net

MODEL RG-40 is a 20-40 KV unit with same specifications as RG-30 except .7 ma. at 40 KV. With meter $375 Net Less meter $325 Net

MODEL 4575 5 KV-1ma. DC POWER SUPPLY

For an output voltage of 5 KV DC at 1 milliampere, the low voltage input requirement is 250 V at 50 milliamperes. By varying the DC input the output voltage can be varied from approx. 1 KV to 7½ KV. Dimensions: 5¾" high x 5" deep x 4¼" wide. In completely enclosed metal housing.

$32.50 Net

MODEL 4575-2. Same as above with 2 ma. output at 5 KV. **$42.50 Net**

MODEL 4575PN—Reversible polarity. High voltage secondary floating or can be grounded. 1 ma. at 5 KV. **$42.50 Net**

MODEL 4575-2PN—Reversible polarity. 2 ma. at 5 KV. **$52.50 Net**

SPELLMAN HIGH VOLTAGE COMPANY

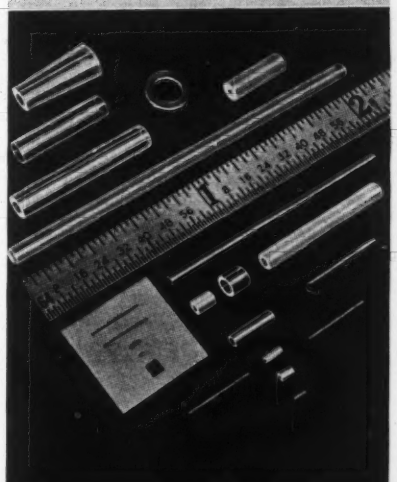
1930 Adee Ave., Bronx 69, N. Y.

Kingsbridge 7-0306

CIRCLE 177 ON READER-SERVICE CARD

PRECISION GLASS
T. H. GARNER COMPANY

MANUFACTURED TO YOUR SPECIFICATIONS



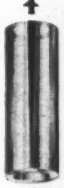
One of a kind, or millions of parts ... you get the closest tolerances from GARNER—tolerances which have led the field in the redrawn glass industry since 1953.

Large stocks of many different glass types and sizes—including the unusual. Available for immediate redraw.

Customer minded—We constantly upgrade equipment and techniques to keep ahead of your needs. You'll find us especially helpful on difficult requirements.

On-time deliveries—GARNER is geared for volume production to tight specifications—on a day-to-day basis. You get the parts you need ... when you need them.

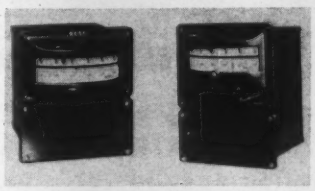
Send for complete data.



T. H. GARNER COMPANY
177 S. Indian Hill Blvd.
Claremont, Calif. • NAtional 6-3526

CIRCLE 178 ON READER-SERVICE CARD

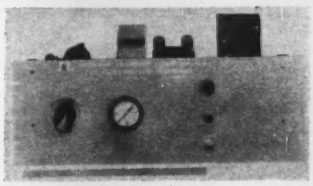
PRESS INDICATOR AND ALARM



New Pressure Indicator for plastic extruders is made as indicator only or with high-pressure alarm. Transducers are of flush diaphragm type, water- or air-cooled. Indicator features push-button calibration. Bulletin S-86. —*West Instrument Corp.*, 4363 *West Montrose Ave., Chicago* 41, *Ill.*

CIRCLE 418 ON READER-SERVICE CARD

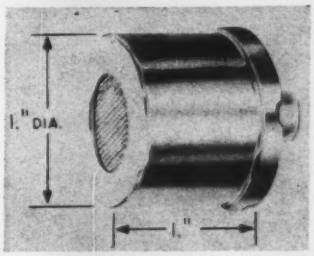
AUTOMATED PRESS CONTROL



New Automated Pressure Controller, Model 407A, produces a regulated air pressure output, externally programmable, which can operate proportionally controlled air actuators directly, or can be used as a proportionally controlled pilot for other water, hydraulic or air systems. Output air pressure can be proportional to coded input signals (audio tones) recorded on magnetic tape.—*Automation Development Corp.*, 11824 *Jefferson Blvd., Culver City, Calif.*

CIRCLE 419 ON READER-SERVICE CARD

TRANSCEIVING TRANSDUCER



New Model TR-7 Transceiving Ultrasonic Transducer (40 kc) is driven by either electron tubes or transistors. As a transmitter, it delivers sound pressure at about +25 db above 1 microbar, at one foot with 25 mw excitation. Receiving sensitivity is approximately 2 mv/microbar.—*Massa Div. Cohu Electronics, Inc.*, 280 *Lincoln St., Hingham, Mass.*

CIRCLE 420 ON READER-SERVICE CARD

TAPE FOR READERS

New mylar/paper, mylar/foil, and metallized-mylar tapes for data processing provide outstanding characteristics specifically designed for photoelectric applications.—*Paper Mfrs. Co.*, 9800 *Bustleton Ave., Phila.* 15, *Pa.*

CIRCLE 421 ON READER-SERVICE CARD

NOW

available from stock

MB model N504 INTEGRATOR AMPLIFIER

- Measure acceleration, velocity, or displacement with conventional accelerometers and vibration meters.
- Measure acceleration or velocity from accelerometer input with standard voltmeters.
- Convert accelerometer signals to velocity for automatic control of vibration exciter displacement, velocity or acceleration.
- Eliminate need for cathode follower and power supply.

SPECIFICATIONS

Frequency Response:	**Amplify Position** (5 cps filter) 10–10,000 cps ±2% 5–10,000 cps ±7% **Integrate Position** (–6 db/octave) 10–2,000 cps ± 5% 5–2,000 cps ±10%
Sensitivity:	**Amplify Position** Maximum gain = 100 **Integrate Position** 1 mv(rms)/"g" peak converted to 96.3 mv (rms)/in./sec.(rms)
Input Impedance:	Greater than 200 megohms
Output Impedance:	Less than 600 ohms

Complete technical details in Bulletin 131. Write...

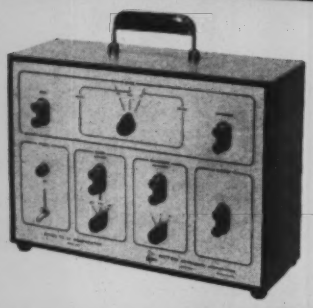
MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC.
1103 State Street, New Haven 11, Conn.

CIRCLE 179 ON READER-SERVICE CARD

If you use an oscilloscope, chances are 4 out of 5 that you need the ROTEK

AC/DC to DC COMPARATOR



TRANSISTORIZED AND MILITARIZED

0.005% COMPARISON ACCURACY AC TO DC

0.001% COMPARISON ACCURACY DC TO DC

FOR

- DYNAMIC PRECISION WAVEFORM ANALYSIS
- AC CALIBRATION
- DC CALIBRATION

The Rotek AC/DC to DC Comparator converts any oscilloscope into a precision waveform analyzer, enabling accurate observation of small, selected portions of large waveforms without oscilloscope overload. For the first time, precision AC versus DC waveform comparison can also be made. The Comparator permits ready examination of AC cycle-to-cycle bounce, modulation, and drift on an oscilloscope, as well as determination of DC amplifier or system low frequency bounce and drift at non-zero outputs.

Please write for Bulletin 212

Other Rotek instruments:
AC Voltage Standards
DC Voltage/Current Standards

ASK FOR DEMONSTRATION

ROTEK INSTRUMENT CORPORATION
733 CONCORD AVE., CAMBRIDGE 38, MASS.
Kirkland 7-0175

CIRCLE 180 ON READER-SERVICE CARD

NEW LITERATURE

CONTROL SYSTEMS AND CONTROLLERS

INDICATOR/CONTROLLER. 6-page Bulletin 4411 describes Type 110 SR-4 pointer indicator and indicating controller, gives selection chart, application system sketches.—Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp., Waltham 54, Mass.

CIRCLE 422 ON READER-SERVICE CARD

ENGINE SAFETY CONTROL. 60-page Catalog J describes a number of complete engine safety control systems incorporating safety shutdown or warning upon malfunction of measured variables such as temperatures, pressures, levels, speed, vibration, etc.—Fulton Sylphon Div., Robertshaw-Fulton Controls Co., Box 400, Knoxville 1, Tenn.

CIRCLE 423 ON READER-SERVICE CARD

CONTROLLERS. 4-page Bulletin 67 describes compact self-balancing indicators and indicator controllers.—Thermo Electric Co., Inc., Saddle Brook, N. J.

CIRCLE 424 ON READER-SERVICE CARD

HI-TEMP INDICATING CONTROLLER. 2-page Design Catalog Sheet describes Type E36N indicating temperature controller.—United Electric Controls Co., 85 School St., Watertown 72, Mass.

CIRCLE 425 ON READER-SERVICE CARD

WATER TREATMENT PLANT CONTROL. 4-page Bulletin 2-1.20-1 describes laboratory control concept in water-treatment-plant design and control.—B-I-F Industries, Box 276, Providence, R. I.

CIRCLE 426 ON READER-SERVICE CARD

SYSTEMS ENGINEERING. 16-page brochure describes facilities, organization, and products of company.—Systems Engineering Labs., Inc., 4066 NE. Fifth Ave., Box 9148, Fort Lauderdale, Fla.

CIRCLE 427 ON READER-SERVICE CARD

VALVES

VALVES. 16-page Bulletin LB-4 describes Series LB all-purpose, split-body control valves.—Conoflow Corp., 2100 Arch St., Phila. 3, Pa.

CIRCLE 428 ON READER-SERVICE CARD

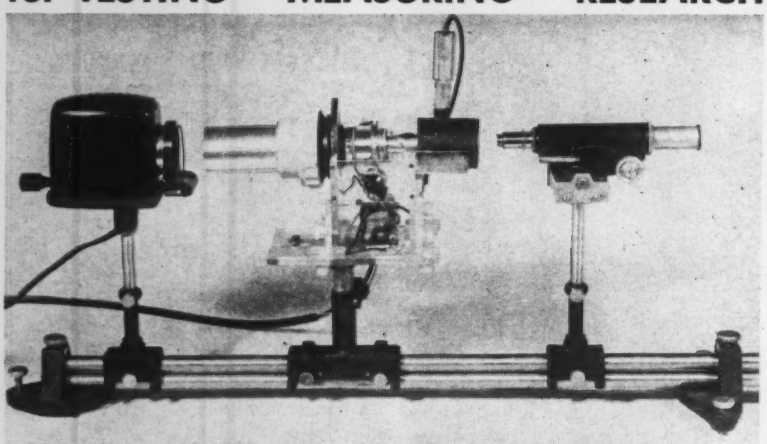
VALVE. 4-page Bulletin S-5 describes cushioned automatic relief-unloading valve for steam, air, gas, and fluid control service.—Golden-Anderson Valve Specialty Co., 1285 Ridge Ave., Pittsburgh 33, Pa.

CIRCLE 429 ON READER-SERVICE CARD

AIR-OPERATED DIAPHRAGM VALVES. 6-page Bulletin 134-A provides data on eight types of air operators for Hills-McCanna diaphragm valves recommended for remote and automatic flow control of corrosive and noncorrosive liquids and gases.—Hills-McCanna Co., 400 Maple Ave., Carpentersville, Ill.

CIRCLE 430 ON READER-SERVICE CARD

for TESTING • MEASURING • RESEARCH



the UNIVERSAL INSTRUMENT BENCH

The Universal Instrument Bench is a basic tool for general research, experimentation, testing, measurement, and production in the Electronic, Electrical, and Optical fields. By employing its component parts, an almost unlimited number of instrumentation devices can be quickly assembled. These devices can be used for assembly line testing of finished equipment, assemblies, and components—making mock-ups and trial tests of proposed instruments—precise alignments and measurements.

For free catalogue write to:

We specialize in manufacturing machined units and assemblies to your specifications.

OK MACHINE & TOOL CORPORATION
551 E. 179th St. New York 57, N.Y. CY-8-0900

CIRCLE 158 ON READER-SERVICE CARD

VISIT BOOTH 605

ISA Show Los Angeles

For everything new in counters and timers

NEW hand-held battery powered 1/10 second digital stop watch.

NEW very inexpensive time base producing up to 10 pulses per sec. to an accuracy of 2.5 sec. per 24 hours.

FIRST algebraic pulse counter—adds and subtracts —indicating plus and minus values.

NEW 1/100 sec. timer with counter readout—capacity to 9999.99 sec.—within the price of standard dial type units.

NEW chart drive with 12 step synchronous variable speed advance.

If you can't visit our booth, write:

PRESIN CO., INC.

2014 Broadway
Santa Monica, Calif.

for information on these and all types of electrical and mechanical counters

CIRCLE 96 ON READER-SERVICE CARD

ELECTRONIC TIMER for automatic operation of electric circuits is described in 4-page Bulletin 120.—Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass.

CIRCLE 451 ON READER-SERVICE CARD

MOTION, VIBRATION

MOTION TRANSDUCERS. 2-page Data Sheet-SPB1 points out capabilities of translatory potentiometers, linear variable differential transformers, and translatory velocity transducers.—Helipot Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.

CIRCLE 452 ON READER-SERVICE CARD

VIBRATION METERS. 4-page bulletin describes Dial-A-Gain double integrating vibration meters.—Unholtz-Dickie Corp., 2994 Whitney Ave., Hamden 18, Conn.

CIRCLE 453 ON READER-SERVICE CARD

GAS, AIR, MOISTURE

GAS DENSITY. 4-page Bulletin GADE 461 describes detectors which compare gas inlet and outlet densities.—Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J.

CIRCLE 454 ON READER-SERVICE CARD

COMPRESSOR INTAKE AIR. 6-page booklet describes Coblentz Dry Air System which provides cold compressor intake air all year around.—Lynch Corp., Glass Machinery Div., Anderson, Ind.

CIRCLE 455 ON READER-SERVICE CARD

MOISTURE TESTS. 12-page Bulletin C describes over 35 new devices for testing soils, concrete, bituminous materials and construction materials.—Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill.

CIRCLE 456 ON READER-SERVICE CARD

RECORDERS

RECORDER. 2-page Bulletin P1289 presents advantages of simultaneous recording of four independent variables on 4-pen electronic Dynamaster recorder.—Bristol Co., Waterbury 20, Conn.

CIRCLE 457 ON READER-SERVICE CARD

PNEUMATIC RECEIVER. 6-page Bulletin A134 contains information on Series 670 Metagraphic pneumatic receiver.—Bristol Co., Waterbury 20, Conn.

CIRCLE 458 ON READER-SERVICE CARD

HIGH DENSITY TAPE RECORDER. 2-page data sheet describes characteristics and operating techniques of PHD-1200 high density system.—Potter Instrument Co., Sunnyside Blvd., Plainview, N. Y.

CIRCLE 459 ON READER-SERVICE CARD

DATA HANDLING

DATA LOGGING SYSTEM. 2-page Data Sheet N-07(4) describes a 160-channel sequential data logging system used in a ceramic plant as a typical case.—Leeds & Northrup Co., 4901 Stenton Ave., Phila. 44, Pa.

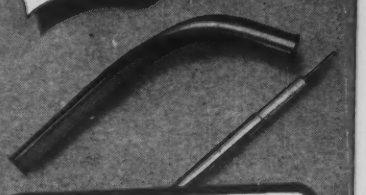
CIRCLE 460 ON READER-SERVICE CARD

DIGITAL LOGGING. 4-page Product Data D400-2 describes Data-Master Digital Logger.—Bristol Co., Waterbury 20, Conn.

CIRCLE 461 ON READER-SERVICE CARD

TUBING

STRAIGHT... PREFORMED OR COAXITUBE



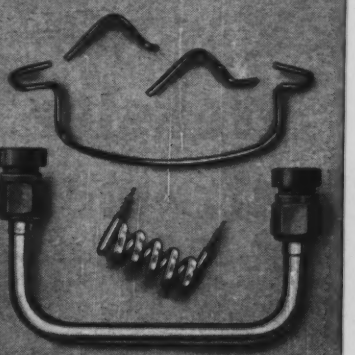
FROM .010" TO 1.000" TO YOUR SPECIFICATIONS

Whatever you need in tubing to any size, shape or alloy . . . Precision can supply it with precision accuracy, extra quality and at no extra cost.

Oxygen free copper and copper alloy tubing, nickel and nickel alloys, aluminum alloys, stainless steel—tubing for all electronic applications. Formed to exact specifications, single or double flared ends, complete with Standard A N Fittings.

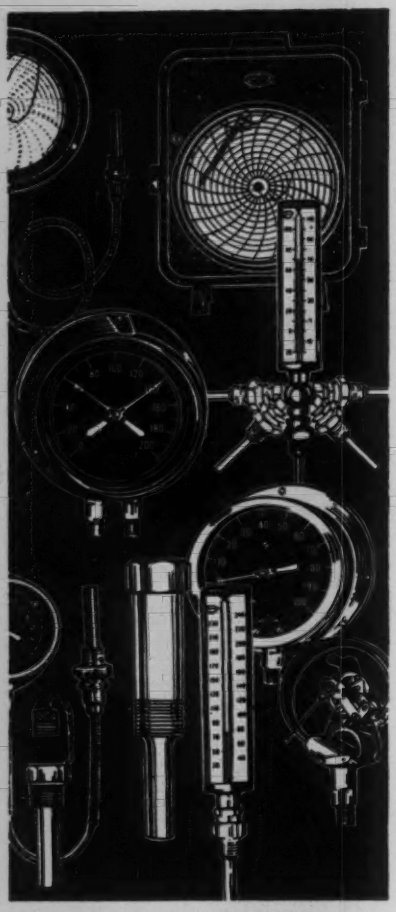
Precision Coaxitube—A semi-rigid coaxial pair of conductors, sub-miniature sizes—low as .050" diameter, polyethylene or teflon dielectrics. Excellent mechanical properties, efficient shielding, low noise level for communication networks and missiles guidance systems — protected from false signals.

Let Precision's engineers help you improve your product and reduce manufacturing costs with preformed tubing, assemblies and Coaxitube. Write for folder and full details to Precision Tube Company, Inc., Dept. 4, North Wales, Pa.



PRECISION TUBE COMPANY

CIRCLE 181 ON READER-SERVICE CARD



SOLVE YOUR PROBLEMS WITH Weksler Instruments

Weksler Instruments for temperature, pressure and humidity applications have been installed in literally thousands of commercial and industrial projects...routine, special, and classified.

Whatever your requirements or problems may be in these types of instrumentation, Weksler may be the one source to meet or answer all of them.

Tell us your instrument needs. We will send you one or more of the five WEKSLER CATALOGS which cover your specific requirements. Advisory services are also available without obligation.

WEKSLER INSTRUMENTS

WEKSLER INSTRUMENTS CORP.
FREEPORT, L. I., NEW YORK

CIRCLE 182 ON READER-SERVICE CARD

CODE CONVERTER. 2-page brochure illustrates and specifies EECO 770D code detector and EECO 770G code generator.—Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.

CIRCLE 462 ON READER-SERVICE CARD

DATA PROCESSING. 8-page Bulletin 3017-B describes Model 210 data acquisition and data processing systems.—Technical Publications Dept., Systems Div., Beckman Instruments, Inc., 2400 Harbor Blvd., Fullerton, Calif.

CIRCLE 463 ON READER-SERVICE CARD

AIRBORNE FM TELEMETERING. 4-page condensed catalog describes line of FM instruments and accessories for airborne telemetering.—Electro-Mechanical Research, Inc., Box 3041, Sarasota, Fla.

CIRCLE 464 ON READER-SERVICE CARD

CARD READER. 2-page Data Sheet DPS-A43 describes CR-201 card reader that transports IBM cards from a card hopper, past two read stations and into a card stacker at 30 cards/min.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 465 ON READER-SERVICE CARD

COMPUTER SIMULATOR. 4-page Bulletin 60-F describes Model 2032 memory system exerciser, an automatic high speed digital computer simulator.—Rese Engr., Inc., A and Courtland Sts., Phila. 20, Pa.

CIRCLE 466 ON READER-SERVICE CARD

DATA PROCESSING. 8-page brochure describes alpha-numeric and numeric interrogators, recently developed keyboard and display devices that allow sending and receiving information to and from remote computers and electronic data processing files.—Information Products Corp., 156 Sixth St., Cambridge, Mass.

CIRCLE 467 ON READER-SERVICE CARD

COMPUTER. 28-page Manual TM 11 presents description, format of instructions, control instructions, etc. for Philco 2000 Translator-Assembler-Compiler.—Philco Corp., Computer Div., Willow Grove, Pa.

CIRCLE 468 ON READER-SERVICE CARD

DATA PROCESSING. Brochure describes Findafact 2510 Data Retrieval System a high-speed transistorized digital data processing that transcribes standard punch card data to magnetic tape.—Rese Engr., Inc., A and Courtland Sts., Phila. 20, Pa.

CIRCLE 469 ON READER-SERVICE CARD

AN/DIG CONVERTER. 4-page Bulletin 1002C illustrates and describes high-speed analog-to-digital converter.—Systems Engineering Labs., Inc., 4066 NE. Fifth Ave., Box 9148, Fort Lauderdale, Fla.

CIRCLE 470 ON READER-SERVICE CARD

ELECTROLUMINESCENT READOUTS. 4-page Brochure ET-3995 illustrates and describes applications of electroluminescent-photoconductive devices in computers, digital voltmeters, circuit alarms, etc.—Sylvania Electric Products Inc., Subs. of General Telephone & Electronics Corp., 1740 Broadway, New York 19, N. Y.

CIRCLE 471 ON READER-SERVICE CARD

INSTRUMENT ENGINEERS

Our worldwide operations result in unusual opportunities for men with five years or more experience in petroleum or chemical plant instrument-application engineering, and field commissioning of instruments. ME or ChE preferred.

Please send confidential résumé to Personnel Department

C F BRAUN & CO
Engineers & Constructors
1000 SOUTH FREMONT
ALHAMBRA, CALIFORNIA

CIRCLE 183 ON READER-SERVICE CARD

REPRESENTATION AVAILABLE

Sales engineers specializing in instrumentation, electronics and automation equipment can accept additional lines in the Houston and south Texas area. We are in intimate contact with chemical, manufacturing, food processing industries and utilities in this territory.

Finlay & Associates
1902 Westheimer
Houston 6, Texas

CIRCLE 184 ON READER-SERVICE CARD

REPRESENTATIVE AVAILABLE

Established engineering and sales company Texas Gulf Coast offers engineering, sales and installation service to instrument or control manufacturer.

Write
ELECTRIC APPARATUS CO.
P.O. Box 2034
HOUSTON 1, TEXAS

CIRCLE 185 ON READER-SERVICE CARD

Man with 15 years **experience** in management, sales and production of electronic components and equipment seeks position as sales manager of director of firm or firms in electro-mechanical components, resistors, pots, etc.
Write ICS Box 386

PERMANENT MAGNET FERRITE ENGINEER

Excellent opportunity for a man with

- B.S. in Ceramic Engineering
- 2 years' experience in hard ferrite production

Duties will involve the establishment and control of an entire ferrite making process.

Company is a leading producer of magnetic materials. Initial assignment will be in New Jersey.

- Salary commensurate with background and experience.

Send complete resume, including salary requirements, to

Box 385

Primary Standards Measurement Engineers

There are openings at Boeing, now, in research, development and maintenance of primary measurement standards. Requirements are a B.S. degree plus experience in precision measurement, or an advanced degree. These positions, offering the opportunity to contribute toward advancement of the state-of-the-art, are in the following areas:

Acoustics	Temperature
Dimension	Infrared
Direct Current	Pressure
Alternating Current	Vacuum
Radio Frequency	Acceleration
Microwave	Optics

Salaries will be commensurate with your education and experience. Write today, to: Mr. W. B. Evans, The Boeing Company, P. O. Box 3707 - IAH, Seattle 24, Washington. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

BOEING

CIRCLE 187 ON READER-SERVICE CARD

LOOP DISCRIMINATOR. 8-page brochure describes phase-locked-loop discriminators for telemetry ground instrumentation.—Electro-Mechanical Research, Inc., Box 3041, Sarasota, Fla.

CIRCLE 472 ON READER-SERVICE CARD

DISPLAY UNITS. 2-page Bulletin 3.4c describes remotely actuated display unit for communications command centers.—Westrex Recording Equipment Div., Litton Systems, Inc., 6601 Romaine St., Hollywood 38, Calif.

CIRCLE 473 ON READER-SERVICE CARD

PROGRAM SIMULATOR. 2-page Brochure illustrates and describes Models PS-425. PS-426, and PS-427.—Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.

CIRCLE 474 ON READER-SERVICE CARD

FILM AND TAPE SPLICERS. 12-page catalog describes company development, splicers, and aperture mounters.—Prestoseal Mfg. Corp., 37-27 33rd St., Long Island City 1, N. Y.

CIRCLE 475 ON READER-SERVICE CARD

TAPE READER. 2-page bulletin describes Model Ptr-71 photoelectric tape reader.—Omnitronics, Inc., Subs. Borg-Warner Corp., 511 N. Broad St., Phila. 23, Pa.

CIRCLE 476 ON READER-SERVICE CARD

TELEMETRY EQUIPMENT. 6-page Data Sheet T-001 describes five equipments for airborne telemetry systems for operation in 215-260 Mc range.—Vitro Electronics, Div. Vitro Corp. of America, 919 Jesup-Blair Dr., Silver Spring, Md.

CIRCLE 477 ON READER-SERVICE CARD

SCANNER TRANSLATOR. 2-page Bulletin DPS/A12 describes with diagrams CM-113 transistorized printed circuit module.—Datex Corp., 1307 South Myrtle Ave., Monrovia, Calif.

CIRCLE 478 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

PANEL INSTRUMENTS. 6-page Bulletin D1-113 describes 4½", 5½", and 7½", 1900 Series a-c and d-c ammeters, milliammeters, microammeters, and voltmeters.—Daystrom, Inc., Weston Instrument Div., 614 Frelinghuysen Ave., Newark 12, N. J.

CIRCLE 479 ON READER-SERVICE CARD

MEASURING-CONTROLLER instrument and electronic controller in one case but operating independently is described in 6-page brochure.—National Electronics, Box 1237, Sheridan, Wyo.

CIRCLE 480 ON READER-SERVICE CARD

SELECTIVE EXPANSION METER with effective 5' scale for d-c measurements accurate to 0.025% is described in 4-page bulletin.—Greibach Instruments Corp., 319 North Ave., New Rochelle, N. Y.

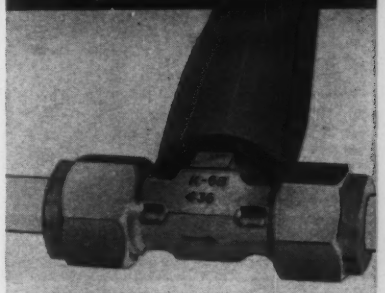
CIRCLE 481 ON READER-SERVICE CARD

DIGITAL VOLTMETER. 6-page Bulletin 311 describes new Model 550 digital voltmeter, gives information for use in data system engineering.—Franklin Electronics, Inc., Bridgeport, Pa.

CIRCLE 482 ON READER-SERVICE CARD

HASTINGS (Thermopile) MASS FLOWMETER

measures flow of air and gases electrically



FEATURES

- high sensitivity—rapid response
- calibration is a function of mass flow
- extreme sensitivity to low flows
- no moving parts—easy operation
- usable from −300°F to +300°F
- undamaged by overload flow or pressure
- rugged and reliable

The Hastings Mass Flowmeter consists of an indicator with power supply and a remotely located flow tube which can be installed directly in the line wherever desired. The flow tube incorporates the Hastings patented heated thermopile which is compensated for temperature and rate of change of temperature.

The Thermopile senses mass flow through the tube and produces an electrical output proportional to the mass flow which is indicated on the readout device. All flow tubes are identical and may be interchanged without recalibration of indicator.

The Hastings Mass Flowmeter is available for measurement in

5 RANGES

1) 0-300 Std. cc/min.
2) 100-1000 Std. cc/min.
3) 300-3000 Std. cc/min.
4) 1000-10,000 Std. cc/min.
5) 3000-30,000 Std. cc/min.

SM-20 Series

For more detailed information send for specification sheet 501. For information on Hastings complete line of Vacuum instruments send for catalog no. 300.

HASTINGS-RAYDIST, Inc.
Hampton, Virginia PArk 3-6531

CIRCLE 188 ON READER-SERVICE CARD

SEARCHLITE SECTION

SMITHS TACHOMETERS

For Precise and Rapid Measurements of

SHAFT SPEEDS CUTTING SPEEDS SURFACE SPEEDS

- **Magnetic Design** Steady readings accurate to ±0.5%
- **Self-Powered** Needs no battery.
- **Hold Button**
- **Overspeed Protection** Inherent
- **Instantaneous Reading** No timing
- Nine Ranges

Complete Service Facilities — Send for Details and Literature

CLARENCE J. MARX CO.

Box 4033, Cleveland 23, Ohio

CIRCLE 189 ON READER-SERVICE CARD

FERANCE BEAM COMPASS

SOLVES Your CIRCLE PROBLEMS

SAVE TIME and MONEY

Beam lengths from 7" to 78½" one piece anodized aluminum. Coursers available in Aluminum, Nylon, or attractive Plastic. Sets available, individually priced from $3.45 or made up to individual requirements. (15% quantity discount on 3 or more sets)

NON-SLIP "GRIP-RINGS" furnished with all points.

Send for Circular and Price List Today

FERANCE Construction Co.

28 Woodside Drive • Penfield, N. Y.

CIRCLE 190 ON READER-SERVICE CARD

FIXED SET THERMOSTATS

Setting Range: —35°C to 370°C

Set Sensitivity: ±.01°C

Accurate control of temperature for all types of equipment. Improved Pressure Loader is designed to insure mercury from separating both in shipping and in use. We can sell direct to you at a saving.

FREE Catalogue Write

PHILADELPHIA SCIENTIFIC GLASS CO.

PERKASIE, PENNSYLVANIA

CIRCLE 191 ON READER-SERVICE CARD

Model HT-12 Four-Range Tachometer

Centrifugal tachometer that measures revolutions per minute and surface speeds.

TOTAL RANGE: 90-12,000 RPM

1st — 90-360 RPM
2nd — 300-1200 RPM
3rd — 900-3600 RPM
4th — 3000-12000 RPM

Feet per minute—one half the dial reading with use of 6" disc wheel.

Advantages: Accuracy—±0.5% • Stop button feature • Instantaneous readings • 3" easy to read dial • Light—approx. 14 oz.

Kemco Instruments Co., Inc.

Box 1284, Church St. Station
New York 8, N. Y.

CIRCLE 192 ON READER-SERVICE CARD

MICROWAVE EQUIPMENT (mixer-preamps, video amplifiers, receivers, etc.) for military and industrial applications is described with specs in 48-page Catalog 61.—Lel, Inc., 75 Akron St., Copiague, L. I., N. Y.

CIRCLE 483 ON READER-SERVICE CARD

AC CURRENT PROBE SYSTEMS. 2-page specification sheet details characteristics of two systems for observation and measurement of current waveforms.—Tektronix, Inc., Box 500, Beaverton, Ore.

CIRCLE 484 ON READER-SERVICE CARD

TESTING

ELECTRICAL TESTERS. 8-page Catalog Cir. Z-54 describes portable matched a-c and d-c industrial meters, current transformer for use as a-c multiplier, etc.—Daystrom, Inc., Weston Instrument Div., 614 Frelinghuysen Ave., Newark, N. J.

CIRCLE 485 ON READER-SERVICE CARD

LIQUID SYSTEM PROBE. 4-page brochure describes Quan-Test Model TF-20 liquid quantity gage system tester.—Consolidated Airborne Systems, Inc., 900 Third Ave., New Hyde Park, L.I., N. Y.

CIRCLE 486 ON READER-SERVICE CARD

CIRCUIT TESTERS. 2-page data sheets describe Fact-Flexible automatic circuit testers, Models C111, RC, and RT. —El Segundo Div., Hughes Aircraft Co., Box 90426, Airport Sta., Los Angeles 45, Calif.

CIRCLE 487 ON READER-SERVICE CARD

RELAYS, SWITCHES

RELAYS. 4-page Bulletin 166 describes new line of GR general purpose relays.—Ohmite Mfg. Co., 3653 Howard St., Skokie, Ill.

CIRCLE 488 ON READER-SERVICE CARD

SWITCHES. 4-page Bulletin P103 describes thermal and waterproof switches.—Control Products Inc., 280 Ridgedale Ave., East Hanover, N. J.

CIRCLE 489 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC COMPONENTS

SELENIUM PHOTOVOLTAIC CELLS. 6-page Bulletin No. 03-201-A discusses features, selection, and applications of an improved selenium photovoltaic cell.—Daystrom, Inc., Weston Instruments Div., 614 Frelinghuysen Ave., Newark 12, N. J.

CIRCLE 490 ON READER-SERVICE CARD

PHOTOCELLS. 4-page leaflet reports on photocell applications.—Photomation, Inc., 96 S. Washington Ave., Bergenfield, N. J.

CIRCLE 491 ON READER-SERVICE CARD

CALIBRATOR FOR TELEMETER RECEIVERS.

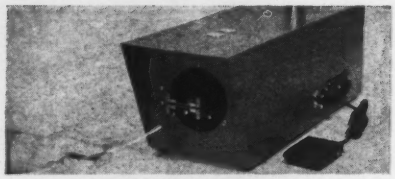
Convenient, fast, one man operation for servicing PDM telemeter receivers such as Bristol, BIF, Honeywell. Can be used as manually set transmitter. **Price $178.**

Contact

BRM Meter Co.,

Box 2821, Los Angeles 54, Calif.

CIRCLE 493 ON READER-SERVICE CARD



AUTO-THERM WIRE STRIPPER for Semi-Automatic Stripping

Strips, Fiberglass, Teflon, Vinyl, cotton, Nylon, etc. Any size to ⅜" diameter including coax, shielded, irregular-shaped. Has solenoid-actuated operation. Rotating head strips hard-to-remove insulation. Capacity in excess of 1000 ends per hour. Heated elements sever the insulation. Cannot nick or cut the finest wire strands. Tension adjustment eliminates crushed wire. Built-in ventilating system. **Price $395 FOB Altadena, Calif.**

Western Electronic Products Co.

2420 North Lake Avenue, Altadena, Calif.

CIRCLE 193 ON READER-SERVICE CARD

ROYSON CONTINUOUS INTEGRATORS

for all applications

3 BASIC UNITS FOR CONTINUOUS INTEGRATION WITH A VARIETY OF INPUTS

- **MECHANICAL INTEGRATOR**—Comes in kit form. Mounts on your recorder, integrates pen position
- **ELECTRONIC MODEL**—Directly Integrates Millivolt or Milliamp Signals
- **PNEUMATIC MODEL**—Integrates 3 to 12 psi pneumatic signals

Send for literature.

WE CAN ENGINEER INTEGRATORS FOR ANY APPLICATION.

Write, wire or phone

ROYSON ENGINEERING

HATBORO, PA. OSborne 5-2800

CIRCLE 194 ON READER-SERVICE CARD

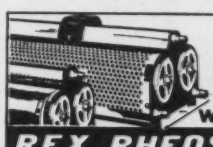
REBUILT INSTRUMENTS

Many Temperature Controllers, Precision Indicators, Continuous Line & Multiple Point Recorders; Leeds & Northrup Speedomax, Micromax; M:H. Brown Electroniks; and other makes. Also Strain Gauge Recorders & Potter Flow Recorders & Indicators.

INSTRULAB, INC.

1205 Lamar St. • Dayton 4, Ohio
BA3-2241

CIRCLE 195 ON READER-SERVICE CARD



TUBULAR RHEOSTATS

Toroid Winding Machines

REX RHEOSTAT CO.

149-d Babylon Tpke. Roosevelt, L. I., N. Y.

CIRCLE 196 ON READER-SERVICE CARD

ICS INDUSTRY NEWS

PERKIN-ELMER announces appointment of *Chester W. Nimitz, Jr.* as a vice president of the Corporation and general manager of its Instrument Division. Mr. Nimitz, Rear Admiral retired, resigned from Texas Instruments, Inc. to accept the position.

BOWMAR INSTRUMENT CORP. announces that a merger with **TECHNOLOGY INSTRUMENT CORP.** is under way.

LEEDS & NORTHRUP announce that *W. Richison Schofield*, a vice president and member of the Board of Directors, recently retired after 45 years with the company.

DAYSTROM CONTROL SYSTEMS announces that *Paul G. Miller* has been appointed general manager of the Control Systems division of Daystrom, Incorporated, following the resignation of Chalmer E. Jones.

ELECTRONIC ASSOCIATES, INC. (EAI) has created a System Analysis Group to study new areas in military and industrial systems where analog computation techniques can be applied. Through its British subsidiary, EAI has opened a **UNITED KINGDOM COMPUTATION CENTER** near London.

DOW CHEMICAL CO. has formed the Instrument Systems Research Laboratory to assist research, engineering, and production with problems relating to instruments and instrument applications. Heading the lab is *Dr. Ormond Barstow.*

HEWLETT-PACKARD has formed a new division for engineering and manufacturing oscilloscopes. Headed by *Cortland Van Rensselaer* as general manager, the new division will be located at Palo Alto. *Robert A. Grimm* is succeeding Mr. Van Rensselaer as general manager of Dymec.

ELECTRO-MECH CORP. has integrated the Reliance Instrument Division and has moved together to its new plant at 500 Livingston St., Norwood, N. J.

PRECISION JEWEL BEARING ASSEMBLIES . . .

for AIRCRAFT • ELECTRICAL MECHANICAL and MARINE INSTRUMENTS

Sapphires set in brass, or other metal assemblies made in any quantity to close tolerance specifications are produced by Moser Jewel Company—*manufacturers of industrial jewels for over 50 years.*

Moser also provides highly polished pivots, staffs —silicon and spring loaded assemblies for high shock resistance.

SEND SPECIFICATIONS — DETAILED INFORMATION READILY GIVEN.

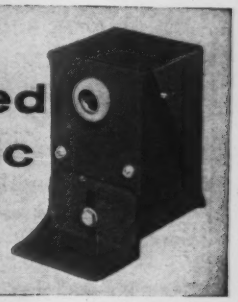
MOSER JEWEL COMPANY

P.O. Box 150 • Perth Amboy, N. J.

"Manufacturers of all types of Industrial Jewels"

CIRCLE 197 ON READER-SERVICE CARD

Transistorized Photoelectric Controls



small remote sensing and light source heads—two of the many items described in the complete catalog.

Built to heavy duty industrial standards. Conservative design provides wide margin of reliable operation, beyond normal variations in line voltage.

Available with self-contained or remote sensing heads and with a wide selection of light sources to meet widely varying application needs.

Complete catalog describes extensive line of transistorized and conventional photoelectric equipment—also includes diagrams of widely varied applications.

Send for catalog or tell us what you want to do.

AUTOTRON, INC.

Box 722Q Danville, Ill.

Hickory 6-0650 TWX: DANV ILL 7338

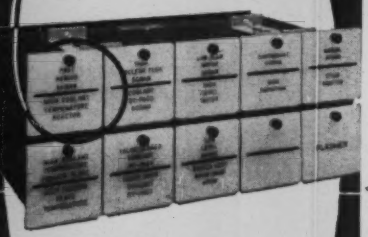
Representatives in principal Cities

CIRCLE 198 ON READER-SERVICE CARD

SCAM

A Heritage of Quality

De-line *TWINPOINT* Annunciator



with new MAGNA-PLAC nameplates

Two complete alarm points in each cabinet position conserve panel area and reduce system cost.

- Nearly 5 sq. inches of engraving area for *each* point
- AO and AF sequences standard
- Conforms to regular De-Line construction features & quality
- All plug-in units are hermetically sealed

SCAM® INSTRUMENT CORP.

3101 N. Lowell Ave., Chicago 41, Ill.

Representatives in all principal cities

FOR MORE INFORMATION

sign and attach coupon to company letterhead.

DEPT. G.

NAME_____

CIRCLE 199 ON READER-SERVICE CARD

ICS ADVERTISERS' INDEX

This Index is published as a service to the subscribers. Every care is taken to make it complete and accurate, but ICS assumes no responsibility for errors or omissions.

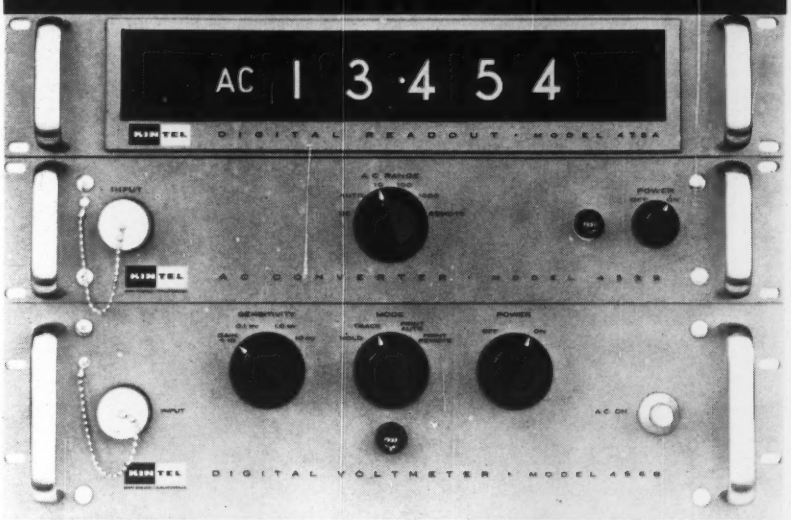
ARCCO Instrument Company, Inc. 1513
Alden Electronic & Impulse Recording Equipment Co., Inc. 1501
Allis-Chalmers, Hydraulic Division 1361
American Machine & Foundry Co. 1487
American Meter Company Incorporated 1537, 1539
American Optical Company 1355
Amot Controls Corporation 1544
Amperite 1372
Anadex Instruments Inc. 1507
Analytical Measurements, Inc. 1528
Annin Company 1373
Assembly Products, Inc. 1529
Associated Research, Incorporated 1386
Astromics a Div. of Mitchell Camera 1511
Automatic Electric 1353
Autotron, Inc. 1553
BRM Meter Co. 1552
Bailey Meter Company 1421
Baldwin-Lima-Hamilton, Electronics & Instrumentation Division 1524
Barber-Coleman Company, Wheelco 1464
Barksdale Valves 1412
Barton Instrument Corporation 1493
Beckman Instruments Inc., Berkeley Division 1478
Boeing Company 1551
Braun & Co., C. F. 1550
Bristol Company 1396, 1397
Brooks Instrument Company, Inc. 1520
Brown & Bro., Inc., Arthur 1537
Brush Instruments, Div. of Clevite ..... B.C.
Burgess Battery Company 1352
Burleigh Brooks, Inc. 1546
Cadillac Products Co. 1546
Clevite Corp., Brush Instruments Div. ..... B.C.
Computer Systems, Inc. 1475
Conoflow Corporation 1415
Consolidated Electrodynamics Corporation 1338, 1339, 1498, 1499
Cox Instruments Division, George L. Nankervis Company 1508
Crawford Fitting Company 1371
Crescent Insulated Wire & Cable Co., Inc. 1391
Crucible Steel Company of America 1390
Crystal Glass Tube & Cylinder Co. 1525
Cubic Corporation 1387
Curtis-Wright Corp., Princeton Div. 1492
Dahl Co., Inc., G. W. 1530
Davis Instruments 1527
Delavan Manufacturing Company 1364
DeZurik Corporation 1418
Di/An Controls, Inc. 1525
Dorsett Electronics, Inc. 1393
Drake Manufacturing Company 1392
Dynamic Research Corporation 1543
Dynel, Inc. 1385
Electric Apparatus Co. 1550
Electro Instruments, Inc. 1379
Electronic Associates, Inc. 1474
Elin Division, International Electronic Research Corporation 1490
Eppley Laboratory, Inc. 1394
Erie Pacific, Div. of Erie Resistor 1497
Esterline Angus Instrument Company, Inc. 1369
Fairchild Controls Corporation 1517
Farris Engineering Corp. 1343, 1395, 1501
Ferance Construction Co. 1552
Finlay & Associates 1550
Fisher Governor Company 1366, 1367
Foxboro Company 1374, 1375, 1423
GPE Controls, Inc. ..... Inside Front Cover
Garner Company, T. H. 1547
Garrett Corporation 1383
General Electric Company 1358, 1359, 1514, 1515
Gow-Mac Instrument Company 1528
Green Instrument Co., Inc. 1384
Gubelman Charts Div. of Nashua Corp. 1342
Hagan Chemicals & Controls, Inc. 1414
Hastings-Raydist, Inc. 1551
Hays Corporation 1341
Heise Bourdon Tube Company, Inc. 1347
Heitz Inc., Karl 1342
Hoke, Incorporated 1413
Hughes Aircraft Company 1399
Hydro-Aire Division of Crane 1502
Hydromatics, Inc. 1505
IBM Data Processing 1380, 1381
Ideal Industries, Inc. 1388
Imperial-Eastman Corporation 1398, 1399
Industrial Electronic Engineers, Inc. 1487
Industrial Instruments Inc. 1526
Industrial Pyrometer & Supply Co. 1507
INSCO Company, Division of Barry Wright Corp. 1382
InstruLab, Inc. 1525, 1552
Instrument Corporation of Florida 1534
Instrument Society of America 1502
International Telephone and Telegraph Corporation 1494, 1495
Jamesbury Corp. 1377
Jerguson Gage & Valve Company 1545
Jones Optical Works, A. D. 1386
Kearfott Division, General Precision, Inc. 1509
Kernco Instruments Co., Inc. 1552
Kin-Tel, A Division of Cohu Electronics, Inc. ..... IBC
Laboratory For Electronics, Inc. 1401
Leeds & Northrup 1405
Leslie Co. 1455
Lewis Engineering Company 1333
Lexington Controls Incorporated 1392
Lincoln Laboratory 1536
Ludlow Papers, A Div. of Ludlow Corp. 1531
MB Electronics 1547
Magnetrol, Inc. 1342
Manning, Maxwell & Moore, Inc. 1409
Markal Co. 1378
Marsh Instrument Company, Div. of Colorado Oil and Gas Corporation 1532
Marshalltown Mfg., Inc. 1536
Martin-Decker Corporation 1378
Marx Co., Clarence J. 1552
Mason-Neilan Division of Worthington Corporation 1362, 1363
MASSA, A Division of Cohu Electronics, Inc. 1496
Mercoid Corporation 1542
Mine Safety Appliances Company 1402, 1403
Minneapolis-Honeywell Regulator Co., Brown Instrument Division 1406, 1407, 1541
Fall River Division 1527
Rubicon Instrument Division 1442
Moore & Company, Samuel 1416
Moser Jewel Company 1553
Nankervis Company, George L., Cox Instruments Division 1508
Nash Engineering Company 1404
New Hermes Engraving Machine Corp. 1530
Non-Linear Systems, Inc. 1356, 1357
O. K. Machine & Tool Corp. 1548
Offner Electronics, Inc. 1348
Ohmart Corporation 1529
P-W Industries 1542
Pace Engineering Company 1545
Palmer Thermometers, Inc. 1540
Panellit, A Division of ISI Incorporated 1408
Parker-Hannifin Corporation 1422
Partlow Corp. 1417
Philadelphia Scientific Glass Co. 1552
Post Electronic Products, Division of Reid Brothers Company, Inc. 1337
Power Designs Inc. 1545
Precision Tube Company 1549
Presin Co., Inc. 1549
Pyramid Plastics, Inc. 1532
Reeves Soundcraft Corp. 1349
Research Incorporated 1541
Rex Rheostat Co. 1552
Rockwell Manufacturing Company 1389
Rosemount Engineering Company 1534
Rotek Instrument Corporation 1548
Royson Engineering 1552
Scam Instrument Corp. 1554
Schutte and Koerting Company 1506
Security Valve Company 1346
Seegers Instrument Company 1535
Sensitive Research Instrument Corporation 1334
Shaw Instrument Corporation 1510
Shore Instrument & Mfg. Co., Inc. 1526
Skinner Electric Valve Division 1470, 1471
Spellman High Voltage Company 1546
Spence Engineering Company, Inc. 1420
Standard Instruments Corporation 1507
Statham Instruments, Inc. 1340
Sticht Co., Herman H. 1526, 1534
Strahman Valves Inc. 1500
Stratos Division, Fairchild Engine & Airplane Corporation 1543
Superior Tube Company 1411
Synchro-Start Products, Inc. 1390
Taber Instrument Corporation 1512
Technique Associates 1382
Teletype Corporation 1351
Texas Instruments Incorporated 1360
Thermco Instrument Corporation 1537
Thermo-Couple Products Co., Inc. 1370
Thermo Electric Co., Inc. 1516
Tigerman Engineering Company 1488
Trans-Sonics, Inc. 1540
Trinity Equipment Corp. 1491, 1538
Uehling Instrument Co. 1528
Unertl Optical Co., John 1536
United Aircraft Corporation, Hamilton Standard Division 1410
United Electric Controls Co. 1376
Valcor Engineering Corp. 1354
Varian Associates 1519
Veeder-Root Inc. 1424
Victor Adding Machine Co. 1419
Waber Electronics, Inc. 1538
Wallace & Tiernan Inc. 1344, 1345
Waugh Engineering Company 1544
Weinschel Engineering Company 1450
Weksler Instruments Corp. 1533, 1550
Welch Scientific Company 1489
Weller Electric Corp. 1518
West Instrument Corporation 1523
Western Electronics Products Co. 1552
Weston Instruments Division, Daystrom, Incorporated 1384, 1400
Wilkerson Corporation 1511
Zeiss, Inc., Carl 1354

NEW!

AC/DC digital voltmeter

EXCLUSIVE FEATURES:

remote (programable) control
up to 10 times more AC and DC resolution
industry's highest AC accuracy



The Model 502B AC/DC Digital Voltmeter measures DC between ±100 microvolts and ±1000 volts, AC from 30 cps to 10 kc between 1 millivolt and 1000 volts. The readout displays 4 digits plus a 5th over-ranging digit (0 or 1) that gives 10 times greater resolution at the decade points (1, 10, 100 volts). The 502B is unique among digital voltmeters in providing AC over-ranging on the two lower manual range scales—00.000 to 19.999 volts and 000.00 to 199.99 volts.

DC measurements are accurate within 0.01% of reading ±1 digit. AC accuracy is the highest in the industry—within 0.1% of reading or ±3 digits from 30 cps to 10 kc for inputs up to 10.000, 100.00, or 1000.0 volts on the respective range scales, within the same tolerance for signals from 50 cps to 7 kc up to 15.000 and 150.00 volts on the respective scales.

The 502B is the only digital voltmeter controllable by remote contact closures. With the AC converter control set to REMOTE, contact closures can select any of the following ranges (1) 10-volt range, AC; (2) 100-volt range, AC; (3) 1000-volt range, AC; (4) auto-range, AC; or (5) auto-range, DC.

Write for detailed literature or a demonstration of this outstanding instrument.

Price $4245.00. Delivery from stock.

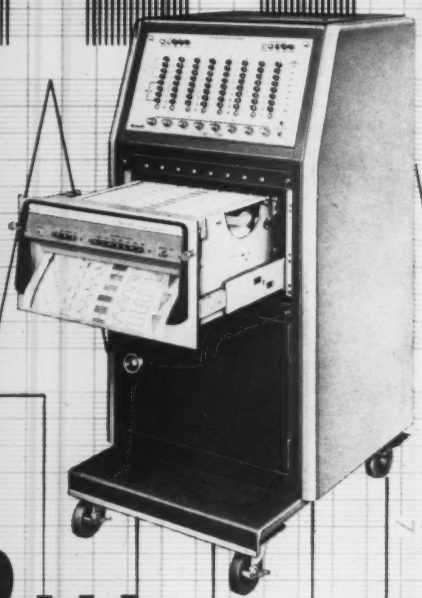
Representatives in all major cities.

5725 Kearny Villa Road, San Diego 11, California • BRowning 7-6700

KIN TEL
A DIVISION OF
COHU
ELECTRONICS, INC

CIRCLE 200 ON READER-SERVICE CARD

COPYRIGHT 1961 BRUSH INSTRUMENTS DIVISION OF CLEVITE CORPORATION CLEVELAND, OHIO



unmatched peak in penmanship...

The totally new Brush Recorder Mark 200 made these incredibly crisp tracings. No other recorder in existence can match them. Note the line width. It never varies . . . regardless of writing velocity, regardless of chart speed. The writing mechanism is electrically signaled by the position-seeking "Metrisite" transducer . . . no parts to wear, infinite resolution, verifiable dynamic ½% accuracy. Traces are permanent, high-contrast, reproducible . . . on low cost chart paper. The Mark 200 has but three standard controls . . . attenuator, pen position, chart speed. Such fidelity, simplicity and economy are possible with no other direct writing recorder. Write for details . . . they'll speak for themselves.

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

CIRCLE 201 ON READER-SERVICE CARD